THE FORRESTER GROUP
INSIGHTFUL ENVIRONMENTAL SOLUTIONS℠

OGDEN FEASIBILITY STUDY
(FINAL)

Union Pacific Railroad Facility
Ogden, Utah
CERCLA-8-99-12

Prepared for

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CONTENTS

APPENDICES

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

Union Pacific Railroad ("UPRR") has been conducting site investigation and remediation activities at the Ogden Rail Yard under the framework of the Comprehensive Environmental Response and Compensation Act ("CERCLA") since 1997. UPRR's current work at the rail yard is being implemented pursuant to a CERCLA Administrative Order on Consent ("AOC") entered into between UPRR and USEPA in 1999 (USEPA Docket No. CERCLA-8-99-12, May 28, 1999). A feasibility study ("FS") is an integral part of the overall site investigation and remediation process.

With respect to the feasibility study, the AOC requires UPRR to conduct a detailed analysis of remedial alternatives (Task VI) including providing USEPA with a Final Feasibility Study report which reflects the findings in USEPA's baseline risk assessment. USEPA guidance on RI/FS format was followed to document the development and analysis of remedial alternatives.

The process and purpose for the FS were restated in the Site Management Plan - Revision 1 (Forrester, July 2003c). Based upon these documents, the purpose of the FS is to provide the basis for the proposed plan for remedial action and documentation of the development and analysis of remedial alternatives. This document also presents an updated evaluation of the remedial action alternatives based on regulatory comments received from the Report on Comparative Analysis.

The USEPA *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA, October 1988), provides the general scope and organization for the FS. Specifically, the guidance provides a suggested FS format and defines various criteria used for the remedial alternatives comparison. This FS follows the suggested format including:

- Review of site background information (Described in detail in the Phase II Remedial Investigation Report and summarized in this FS, but not discussed in this Executive Summary)
- Definition of remedial action objectives
- Development and detailed analysis of alternatives

- Recommendation of a selected alternative based upon a comparative analysis of alternatives

REMEDIAL ACTION OBJECTIVES

The FS content has generally been divided into two basic areas: the Northern Area ("OU-01") and the Ogden Rail yard Groundwater ("OU-04").

Northern Area

RAOs for the Northern Area OU ("OU-01") are as follows:

1. Protect human and ecological receptors from exposure to DNAPL contaminated sediments at the 21st Street Pond.
2. Prevent unacceptable exposure risk to current and future human populations presented by direct contact, inhalation, or ingestion of contaminated groundwater.
3. Prevent potential future groundwater plume migration as necessary to protect current beneficial uses and potential beneficial uses of groundwater in the vicinity of the site, and to be protective of surface waters and their designated uses.
4. Restore the groundwater to beneficial uses (as technically practicable).
5. Treat, contain, or remove DNAPL to prevent or minimize further spread of the DNAPL.

Rail Yard Groundwater

RAOs for the Rail Yard Groundwater OU ("OU-04") are as follows:

1. Prevent unacceptable exposure risk to current and future human populations presented by direct contact, inhalation, or ingestion of contaminated groundwater.
2. Prevent potential future groundwater plume migration as necessary to protect current beneficial uses and potential beneficial uses of groundwater in the vicinity of the site, and to be protective of surface waters and their designated uses.

3. Restore the groundwater to beneficial uses (as technically practicable).

4. Treat, contain, or remove sources of ongoing contaminant loading to the groundwater plumes.

DEVELOPMENT AND EVALUATION OF ALTERNATIVES

An initial selection of technologies which appear to be the most likely candidates for implementation at the Ogden Rail yard site was completed at an earlier time as a preliminary step in the FS process. The initial screening that was performed and the RAOs agreed to with the agencies were used to develop the list of alternatives provided below.

Northern Area Operable Unit

Remedial Action alternatives evaluated for the Northern Area OU ("OU-01") are as follows:

1. No Further Action.

2. Interim actions implemented to date with Monitored Natural Attenuation and institutional controls. Actions implemented to date include the fence around the DNAPL-impacted sediments, pond water level management, and limited DNAPL recovery. Additional groundwater sampling will be conducted to monitor DNAPL-related contaminant levels in groundwater.

3. Pond sediment containment remedy with DNAPL recovery and institutional controls. Screening and refinement of the pond sediment remedies previously presented in the Focused Feasibility Study was performed to identify the preferred remedy for the DNAPL-impacted sediments in the 21st Street Pond. A DNAPL recovery alternative based on the results of the DNAPL recovery pilot test and the additional DNAPL zone characterization work will be developed. It is anticipated that this alternative will focus on application of the dual phase recovery method (the technology successfully used in the pilot test) in stratigraphic lows where continuous phase DNAPL exists in the greatest quantities. Additional groundwater sampling will be conducted to monitor DNAPL-related contaminant levels in groundwater.

4. Pond sediment excavation remedy with intensive DNAPL zone treatment and institutional controls. This alternative incorporates a more intensive DNAPL zone treatment approach that maximizes reduction of contaminant mobility, volume, and toxicity with the goal of full restoration of beneficial use. The specific treatment approach that was incorporated into the alternative is dynamic underground stripping (a steam technology).

5. Pond sediment excavation remedy with DNAPL recovery and institutional controls. This alternative incorporates removal of the impacted sediments from the 21st Street Pond as described in Alternative 4, and the DNAPL recovery described in Alternative 3.

Rail Yard Groundwater Operable Unit

Remedial Action Alternatives to be evaluated for the Rail Yard Groundwater OU ("OU-04") are as follows:

1. No further action.

2. MNA. Evaluation of this alternative will incorporate the results of the additional groundwater monitoring and natural attenuation characterization work.

3. Focused source removal with MNA. This alternative will include actions to address the wastewater sewer lines and machine shop associated with the former Southern Pacific Railroad ("SP") facilities, which appear to be a potential source of ongoing CVOC loading to the North CVOC Plume.

4. Aggressive source area remediation with MNA. This alternative will include actions to more aggressively treat potential sources of ongoing CVOC loading to the North CVOC Plume. This alternative considers air sparging in the zones of highest CVOC concentration.

5. Perimeter groundwater treatment. This alternative will include actions to actively treat groundwater along the site perimeter, to mitigate the potential for offsite migration of CVOC-impacted groundwater. This alternative is comprised of a line of air sparging

wells that will create a treatment zone through which impacted groundwater must pass before offsite migration.

6. Aggressive Source Area Remediation and active groundwater remediation with the objective of restoration of groundwater beneficial use as expeditiously as possible. This alternative considers air sparging over the entire extent of VC impacts.

Evaluation Criteria

For a remedial action to meet the statutory requirements, it must:

- Be protective of human health and the environment.
- Attain ARARs or provide grounds for invoking a waiver.
- Be cost-effective.
- Use permanent solutions and alternative treatment technologies, or resource recovery technologies, to the maximum extent practicable.
- Satisfy the remedial action objectives or satisfy the preference for treatment that reduces toxicity, mobility, or volume as a principal element.

In addition, other statutory requirements emphasized by the Comprehensive Environmental Response, Compensation, and Liability Act ("CERCLA") include an evaluation of the long-term effectiveness and the following related considerations:

- The persistence, toxicity, and mobility of the hazardous substances and their constituents.
- Short- and long-term potential for adverse health effects from human exposure.
- Long-term maintenance costs.
- The potential threat to human health and the environment associated with excavation, transportation and re-disposal, or containment.

These requirements have been condensed into nine evaluation criteria, which serve as the basis for evaluating the alternatives in the detailed analysis. These nine criteria include: overall protection of human health and the environment; compliance with ARARs; long-term effectiveness and permanence; reduction of toxicity, mobility, or volume; short-term effectiveness; implementability; cost; state acceptance; and community acceptance.

The evaluations of alternatives relevant to the evaluation criteria for the Northern Area Operable Unit and the Rail Yard Groundwater Operable Unit are provided in Tables 4-1 and 7-1, respectively.

SELECTED REMEDY BASED UPON ALTERNATIVES COMPARISON

Northern Area Operable Unit

Based on the comparative analysis, key remedy selection considerations are as follows:

- The UPRR Project team is not aware of any site with a large DNAPL zone at which restoration to drinking water quality criteria throughout the impacted zone has been achieved and documented. Based in part on this finding, groundwater restoration (that is, achievement of MCLs throughout the DNAPL impacted zone) is considered technically impracticable.

- Alternative 3 reliably achieves all of the remaining RAOs in a relatively short time period (that is, a few years).

- Alternative 3 addresses the DNAPL impacted pond sediments by capping them in place. Once these sediments are capped, human and ecological receptors will be protected from direct exposure to the sediments. Capping the DNAPL sediments in place is consistent with the remedial action component for the DNAPL zone (waterflood DNAPL recovery), in that both alternatives will rely on institutional and/or engineering controls to manage the potential risk posed by residual DNAPL-impacted soils and sediments.

- Relative to Alternative 3, Alternatives 4 and 5 incorporate a significantly higher level of effort and cost in reducing contaminant concentrations. However, even after this more intensive and costly remedial action effort, long-term site management requirements (for example, the need for institutional controls to manage residual impacts) would remain essentially the same as for Alternative 3.

- Alternatives 4 and 5 include excavation and off-site disposal of DNAPL-impacted sediment and soil from the 21st Street Pond. Although the intent of the excavation is to remove all of the impacted sediment and soil, it is possible that a fraction of the material may not be removed due to limitations in locating the impacted material and in effectively removing the sludge and soil from the saturated pond bottom. Confirmation sampling also has its limitations with regard to verifying that all DNAPL-impacted material has been removed. Therefore, although excavation will remove the majority of the DNAPL-impacted soil and sediment, residual materials that are not identified and/or not removed may create a potential for future DNAPL exposure.

- Alternative 4 poses a significant challenge with respect to protection of human health and the environment during remedial action. Because the DUS process relies on making the DNAPL more mobile, there is an accompanying potential for unintended contaminant redistribution. Preventing the mobilized DNAPL from impacting water quality in the 21st Street Pond would be of particular concern.

Based on alternative comparison, including the above considerations, Alternative 3 is the preferred alternative. Alternative 3 clearly provides greater value than the other alternatives. In summary, the recommended alternative consists of the following:

- DNAPL impacted 21st Street Pond sediments will be contained and capped in place. A cofferdam will be constructed in the pond's southeast corner to segregate the DNAPL impacted sediments from the remainder of the pond, and then the sediments will be backfilled to eliminate the potential exposure pathway. The estimated construction time for capping the sediments in place is 16 weeks.

- DNAPL recovery will be performed to deplete continuous phase DNAPL. A maximum of four pools of potentially recoverable DNAPL have been identified and each will be depleted to the extent practicable. DNAPL recovery will be performed by applying the pumping recovery technologies used during the 2002 pilot DNAPL recovery project. The estimated time to complete DNAPL recovery of these areas is 3 years.

- Institutional controls will be applied to ensure that direct contact, inhalation, and ingestion of impacted groundwater will continue to be an incomplete exposure pathway. Institutional controls to could be applied in short time period. Monitoring will continue to be performed to ensure that surface water and other groundwater in the vicinity of the site are protected.

Rail Yard Groundwater Operable Unit

Based on the comparative analysis, key remedy selection considerations are as follows:

- Natural attenuation processes at the site are very significant in limiting plume migration, providing complete dechlorination of chlorinated solvent constituents to innocuous byproducts, and even in reducing plume extent (as data for the South VOC plume suggests). The UPRR project team is unaware of a single site in the country where natural attenuation processes are performing any better with respect to control of chlorinated solvent plume migration. The site is an ideal candidate for a groundwater remedial action approach that incorporates MNA as a key component.

- Sludge in abandoned sewer lines appears to be a source of continued contaminant loading to the northern CVOC plume. Cleaning and/or grouting and capping of the sewer lines coupled with removal of heavily impacted soil (as appropriate) is a cost-effective source control measure. The effectiveness of more intensive source control efforts is uncertain, particularly if there are any small pockets of chlorinated solvents present in the form of DNAPL (as suggested by some of the data).

- There is no clear advantage in the ability of aggressive remediation options to achieve the RAOs compared to Alternative 3. All of the alternatives (except the No Action alternative) are capable of achieving all the RAOs in a short time period, except the RAO of restoring the groundwater to beneficial uses (as technically practicable).

- The timeframe for groundwater restoration with MNA is reasonable compared to aggressive groundwater treatment. Aggressive source area treatment likely reduces the time required to achieve site restoration, but the increased cost of more aggressive treatment do not provide certainty regarding the magnitude of the reduction.

- The timeframe for groundwater restoration with MNA and focused removal is reasonable compared to MNA with aggressive source removal. Spending a substantial amount more for aggressive treatment is not appropriate given the ability of Alternative 3 to achieve all the RAOs, and the uncertainty in the ability of aggressive removal options to achieve meaningful source removal and shortened cleanup times.

In summary, the recommended alternative consists of the following:

- Institutional controls will be used to prevent future exposure to contaminated groundwater.

- Monitored natural attenuation will be used to monitor the plume and ensure that the plume is not migrating and that surface waters are protected.

- Focused source removal will be performed to remove a significant source of groundwater contamination. Focused source removal will consist of; (1) cleaning and in-place abandonment of PVC and steel tributary sewer lines, (2) cleaning removal of the main 10-inch diameter sewer trunk line composed of vitrified clay pipe, and (3) removal of the most heavily impacted material (i.e., visually impacted soil and bedding) from the trunk line excavation.

1 INTRODUCTION

1.1 PURPOSE AND ORGANIZATION OF REPORT

Union Pacific Railroad ("UPRR") has been conducting site investigation and remediation activities at the Ogden Rail Yard under the framework of the Comprehensive Environmental Response and Compensation Act ("CERCLA") since 1997. UPRR's current work at the rail yard is being implemented pursuant to a CERCLA Administrative Order on Consent ("AOC") entered into between UPRR and USEPA in 1999 (USEPA Docket No. CERCLA-8-99-12, May 28, 1999). A feasibility study ("FS") is an integral part of the overall site investigation and remediation process.

With respect to the feasibility study, the AOC requires UPRR to conduct a detailed analysis of remedial alternatives (Task VI) including providing USEPA with the following deliverables:

Report on Comparative Analysis and Presentation to USEPA. UPRR submitted a Report on Comparative Analysis to USEPA summarizing the results of the comparative analysis performed between the remedial alternatives. This document was submitted on October 21, 2003. On November 6, 2003, UPRR made a presentation to USEPA and UDEQ during which the UPRR project team summarized the findings of the remedial investigation and remedial action objectives, and presented the results of the nine criteria evaluation and comparative analysis of the selected remedial action alternatives.

Draft FS Report. With this current document, UPRR is submitting a Draft Feasibility Study report which reflects the findings in USEPA's baseline risk assessment. T his document also presents an updated evaluation of the remedial action alternatives based on regulatory comments received from the Report on Comparative Analysis. USEPA guidance on RI/FS format was followed to document the development and analysis of remedial alternatives.

The process and purpose for the FS were restated in the Site Management Plan - Revision 1 (Forrester, July 2003c). Based upon these documents, the purpose of the FS is to provide the basis for the proposed plan for remedial action and documentation of the development and analysis of remedial alternatives.

The USEPA *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA, October 1988), provides the general scope and organization for the FS. Specifically, the guidance provides a suggested FS format and defines various criteria used for the remedial alternatives comparison. This FS follows the suggested format including:

- Introduction including site description, site history, nature and extent of contamination, contaminant fate and transport, and baseline risk assessment (relying on the results and conclusions from the Remedial Investigation).

- Identification and screening of technologies (relying upon preliminary work completed by Safety-Kleen in June 2000 and The Forrester Group in November 2001; Appendix A). Because this is a streamlined FS, only a summary of the results of the preliminary work completed by Safety-Kleen has been included in this document.

- Development of alternatives.

- Detailed analysis of alternatives.

- Comparative analysis of alternatives.

The FS content has generally been divided into two basic areas: the Northern Area ("OU-01") and the Ogden Rail yard Groundwater ("OU-04"). This division of the FS was done to streamline review and comment by various project stakeholders such as UPRR, Utah Department of Transportation ("UDOT"), UDEQ, and USEPA, and because UDOT has been named as a potentially responsible party ("PRP") for a portion of the northern area ("OU-01").

1.2 BACKGROUND INFORMATION (CONCEPTUAL SITE MODEL)

This section provides background information relative to the UPRR Ogden Rail yard. This information is consistent with and derived from the AOC and the Remedial Investigation Report (Forrester, September 2003a). A more complete bibliography of site documents is presented in the 2003 Site Management Plan, Revision 1, Section 8 (Forrester Group, 2003c).

1.2.1 Site Description

The areas evaluated in the FS are described below including a brief description of site layout and a summary of surface water, soil, and groundwater conditions. The Ogden Rail Yard is described first as it provides a general overview of the site associated with the Ogden Rail Yard including underlying soil and groundwater. The Northern Area, including the 21st Street Pond, is described next as this description builds upon the Rail Yard description, but focuses on a smaller area within the Ogden Rail Yard site.

1.2.1.1 Rail Yard

The Ogden Rail Yard is located in Weber County, Utah, to the west of the City of Ogden (Figure 1-1). The Rail Yard generally extends from Riverdale Road on the south, to the Ogden River (20th Street) on the north; and from the Weber River on the west, to Wall Avenue and Pacific Avenue on the east. The Rail Yard is elongated in a north-south direction over a distance of 3.4 miles, and occupies the floodplain on the east side of the Weber River. The mean elevation above sea level across the site is about 4,300 feet. Ground surface elevations range from a high of 4,349 feet at the southern terminus of the Yard (Area of Interest ("AOI") - 12), to a low of 4,280 feet at the northern end of the Site ("AOI-35"). Most of the site consists of a flat, open yard, with both railroad-related facilities and private industrial facilities located at various positions along the perimeter. The operating portion of the Yard, generally extending from the westernmost track areas to the eastern boundary, is variably covered with concrete, asphalt, rail track, or non-vegetated soil. The western border of the site contains wildlife habitat areas situated between the Weber River and western extent of railroad operations.

SURFACE WATER

Figure 1-2 illustrates surface water features at the site. A man-made pond known locally as the 21st Street Pond ("AOI-33") is adjacent to the northern edge of the Rail Yard. (AOI-33 is discussed in more detail in Section 1.2.3.2). The Weber River flows northward along the western side of the site, after which the channel turns westward at the north end of the Rail Yard and joins the Ogden River about a mile further downstream. The elevation of the Weber River falls about 60 feet between the southern end of the rail yard at the Riverdale Street overpass and the northern (downstream) end of the rail yard at 21st Street. The Weber River is typically a losing stream with respect to the adjacent bank area. This is consistent with the conceptual model that has been developed by the USGS for mountain streams along the Wasatch Front.

Standing surface water is non-existent in the operating portion of the Rail Yard, with the exception of intermittent pools following storm events. Standing water has been noted in low areas between the westernmost tracks and the Weber River. One such area is "Ogden Pond" (AOI-27) which intermittently contained standing water depending on the season. In July 2004, a removal action was completed in this AOI which included installation of a soil cap. The cap elevated the former ground surface by one foot or more, thus eliminating future accumulation of standing water at this location (Kennedy/Jenks, 2004). Four surface drainage ditches listed below cross through the Yard and discharge to the Weber River. Sources of water in these ditches are located in the City east of the Site.

- Burch Creek, AOI-9
- Strongs Creek, AOI-29
- 33rd Street Slough
- Unnamed intermittent drainage, AOI-10

SOIL

The uppermost soil type at the site is typically fill. The fill consists of a wide variety of materials, ranging from silts to gravels, with construction debris and coal/cinders. In the rail yard, fill extends to a minimum depth of 4 feet. General lithologic or native "soil" units underlying the fill have been found to be laterally consistent throughout the site (Figure 1-3). These units are:

- A section of graded bedding (overbank deposits) composed of silty clay and fine grained sand facies that grades downward through fine sand to coarse sand.
- Channel deposits consisting of sandy gravel that underlie the overbank deposits. In general, the channel deposits begin at the water table and extend to the Alpine Formation clay.

- Underlying the gravel unit is thick lacustrine clay believed to represent the upper part of the Alpine Formation, based on its depth of occurrence and continuity across the entire rail yard. This clay is regionally extensive in the Ogden area. Reaching a thickness of 200 feet, the Alpine forms a confining layer for shallow aquifers (Feth et al., 1966). In the vicinity of the site, the Alpine Clay is estimated to be over 50 feet thick, based on a 125-foot measured section located 3100 feet east of the site, and on site borings that have drilled 22 feet into the Alpine without going through it.

GROUNDWATER

The groundwater zone of primary interest beneath the Ogden Rail Yard is the saturated alluvial zone (Figure 1-3). This zone is continuous across the site, and is comprised of channel deposits containing poorly sorted gravel in a matrix of silt and fine-grained to medium-grained sand. This zone typically exists from the water table down to the Alpine Clay. Given the variable depth to the Alpine Clay, the thickness of the saturated alluvial zone ranges from 1 to 22 feet, with a typical thickness of 10 to 12 feet.

Alluvial groundwater at the Rail Yard generally flows toward the north/northwest at an estimated velocity of 5.6 and 11 feet/day in the northern and southern portions of the Rail Yard, respectively (Figure 1-4). As discussed above, the Weber River is a losing stream with respect to the alluvial groundwater. The losing nature was determined from hydrostatic elevation data that was generated for the Weber River and four monitoring wells at various distances from the river in the Remedial Investigation (Forrester Group, 2003a, Part 1, Section 3.3.1). This relationship would tend to keep the alluvial groundwater from discharging to the Weber River.

The Rail Yard alluvial groundwater is protected as a potential drinking water source because it is classified as a Class II aquifer (UAC R317-6-3.5). However, given the continued industrial/commercial use of the site (as recognized in the AOC) and the location of the site within the boundaries of the City of Ogden's municipal water supply system, use of the alluvial groundwater for water supply (particularly for potable purposes) is not plausible. Potential downgradient groundwater receptors are located off-site.

1.2.1.2 Northern Area

The area encompassing a hydrocarbon-based dense non-aqueous phase liquid ("DNAPL") zone, 21st Street Pond, and adjacent sections of the Ogden River is referred to as the "Northern Area" of the rail yard. Topography is generally level across the site, and the ground surface elevation averages 4,290 feet. The main north-south rail line from the Ogden yard passes along the eastern side of the site.

A Pintsch Gas Works facility that historically was located at the northern end of the rail yard is believed to be the source of the DNAPL. The facility manufactured an illumination gas used to light rail cars. Research into the site history shows that this facility operated from 1891 to no later than 1935. The DNAPL zone generally extends northward from the suspected source area toward the 21st Street Pond and underneath the Ogden River. The extent of the DNAPL zone is shown in Figure 1-5.

SURFACE WATER

The Ogden River flows westward through the northern part of the site. The Ogden River's hydraulic gradient in the stretch adjacent to the site is approximately 17 feet per mile. Based on an elevation survey that was conducted along the length of the Ogden River, the deepest part of the stream bottom ranged from 0.5 to 4.8 feet deep. River flow is controlled mainly by precipitation events (rainfall, snow melt) and release from the Pineview Dam located upstream of the City of Ogden.

The 21st Street Pond covers about 25 acres on the north end of the site. Historical photographs show previous land use as being agricultural, prior to the excavation of the pond as a gravel pit by the Utah DOT in 1973. Water levels in the 21st Street Pond are mainly controlled by inlet and outlet sluice gates which are connected directly to the Ogden River. During times of low water, the pond depth varies from 0.6 feet in the eastern end to 5.6 feet in the northern end.

The 21st Street Pond is owned by the State of Utah DOT. It was previous owned by the Utah Department of Natural Resources ("DNR"), Division of Parks and Recreation and managed as a recreational fishing pond as part of Fort Buenaventura Park. As a protective measure, the pond was closed for fishing in June of 2000, due in part to detection of PCBs in the tissue of fish in the pond that were sampled by the EPA during a portion of the Phase II Investigation. As a result of budget cuts, DNR transferred ownership of the remaining portion of Fort Buenaventura Park to Weber County in July 2002. Weber County is presently the owner and manager of Fort Buenaventura Park. Regardless of the future fishery designation of the 21st Street Pond, it is anticipated based on meetings with UDOT and Ogden City, that the area will continue to have a recreational use in the future by being incorporated into the City of Ogden's Ogden River Parkway system.

The Weber River is not significant relative to groundwater flow in the vicinity of the DNAPL zone or the 21st Street Pond.

SOILS

The lithology of soils in the Northern Area is very similar to that of the Rail Yard (Figure 1-3). Principle stratigraphic units of concern at the site are alluvial deposits associated with the Weber and Ogden Rivers and an underlying lacustrine clay. In descending order, the soils encountered include fill, overbank silts, point bar sands, channel gravels, and lacustrine clay. The gravel deposits and clay are continuous and generally uniform beneath the site.

The contact between the clay and overlying gravel is typically sharp. The depth of the clay is variable across the area of investigation and ranges from measured depths of 7.4 to 29.2 feet below ground surface. Field evidence supports the determination that this clay is an effective barrier to downward migration or flow of the identified DNAPL. All borings completed within the area of hydrocarbon contamination show that the DNAPL is pooled on the clay surface and does not penetrate it.

GROUNDWATER

South of the Ogden River, the general direction of groundwater flow at the northern area is to the west/northwest. The eastern end of the 21st Street Pond acts as a sink for groundwater flow (Figure 1-5). The higher water table throughout the site, relative to the pond surface, is manifested by groundwater seeps that are present along the banks of the pond.

The Ogden River is generally a losing stream in the reaches over the DNAPL zone. Downstream of the DNAPL zone, the river-groundwater interaction is overshadowed by the sink effect of the

21st Street Pond. In this area, all groundwater flow south of the Ogden River is toward the pond. North of the river in the vicinity of the DNAPL zone, the primary groundwater flow direction is parallel to the river. Along the north bank of the river downstream of the DNAPL zone, there may be components of lateral groundwater flow in the southward direction. However, given the sink effect of the 21st Street Pond and the losing-stream status of the river, it is believed that groundwater which may have a flow vector toward the river would actually flow beneath the river channel and into the 21st Street Pond. (This is manifested by the potentiometric contours on Figure 1-5 between the pond and well 33-MW12FP.)

Groundwater flow is mostly through the channel gravels above the clay. The groundwater gradient in areas of the site located away from the pond ranges from 0.003 ft/ft to 0.008 ft/ft. Nearer the pond, the gradient is 0.084 ft/ft. Based on aquifer testing, the hydraulic conductivity of the channel gravels is 0.1 cm/sec.

Like alluvial groundwater at the Rail Yard, groundwater at the Northern Area is protected by the State as a potential drinking water source. However, use of the alluvial groundwater for water supply is not likely given the site's continued recreational/commercial use and proximity to municipal water supply.

1.2.2 Site History

The Site was first used as a rail yard by the Central Pacific (predecessor of the Southern Pacific) and Union Pacific railroads in 1869. Since that time, four railroad companies -- UPRR, Southern Pacific Railroad ("SPRR"), Denver and Rio Grande Western Railroad ("D&RGW"), and the Ogden Union Railway and Depot Company ("OUR&D") -- built and operated on various portions of the Site. SPRR and D&RGW operated in the northern portion of the Site, while UPRR and OUR&D operated in the southern portion of the Site. With the completion of the UPRR-SPRR merger in 1996, the entire Yard is now under the ownership of UPRR, with the exception of the metal-recycling facility owned and operated by Atlas Steel – Western Metals ("AOI-21").

Facilities previously located at the Site include coal yards, freight houses, passenger service depots, switching yards, machine shops, boiler shops, transfer tracks, oil/water treatment plants, fuel storage tanks, cold storage houses, warehouses, offices, turntables, and roundhouses. These facilities were needed to support the various maintenance and business activities related to operation of the railroads. Use of the various facilities at the Site has declined significantly and the majority of the old shop buildings have been demolished.

Both railroad-related facilities and private industrial facilities are located at various points along the perimeter of the yard. Additional industrial facilities, on both privately held property and on property leased from UPRR, are located within the confines of the Yard.

1.2.3 Nature and Extent of Contamination

1.2.3.1 Rail Yard

The most significant groundwater impacts at the site are limited to the vicinities of most intensive industrial activity. There are two major zones of impact as shown on Figure 1-6. Both zones are impacted by fuel hydrocarbons and chlorinated solvents.

This first zone, called the south plume, originates from the vicinity of the former location of the UPRR Roundhouse ("AOI-22b"). In this zone, there is an area in which historic releases of diesel fuel have apparently resulted in the sporadic occurrence of fuel hydrocarbons in the form of LNAPL over an area of approximately 1.2 acres. This LNAPL zone is located within the extent of a groundwater zone impacted by a variety of chlorinated volatile organic compounds ("CVOCs"). The CVOCs are believed have resulted from historic releases of chlorinated solvents and their subsequent degradation. The constituent that has the most widespread occurrence is vinyl chloride, which is believed to be a degradation product of TCE and/or 1,1,1-TCA (see Appendix B). The CVOC plume is roughly circular in shape, covering an area of approximately 17 acres, and also extends to the area of AOI-26.

The second zone, called the north plume, likely originates from the former location of the SPRR Roundhouse ("AOI-22a"), and Engine Maintenance Area and Machine Shop ("AOI-38"). In this zone, there are two fuel hydrocarbon LNAPL zones. The LNAPL zones cover areas of approximately 10 acres and 1.2 acres. These LNAPL zones are almost completely underlain by a groundwater zone impacted by a variety of CVOCs. The CVOC plume is an elongated oval in shape, extending downgradient from the source area to northwest of the former SPRR Waste Water Treatment Plant ("AOI-34"). The CVOC plume covers an area of approximately 41 acres. The constituent that has the most widespread occurrence is again vinyl chloride. Vinyl chloride found in the north plume is likely the product of chemical transformation of PCE, TCE, and 1,1,1-TCA (see Appendix B).

PLUME SOURCE AREAS

The hydrocarbon LNAPL was sampled to determine if solvents had partitioned into the LNAPL in sufficient concentrations. No CVOCs were detected in the samples therefore it is unlikely the LNAPL is the source of the aqueous phase CVOC plumes. Additional investigations evaluated the potential presence of free-phase chlorinated solvents in the form of DNAPLs, which could serve as an ongoing source of aqueous phase CVOCs. No free-phase chlorinated solvents were found. Based largely on the relatively high concentrations found and probability of historic solvent use at AOI-38 (as a degreaser in heavy equipment repair), it is concluded that chlorinated solvent DNAPL could be present at the site, although no chlorinated solvent DNAPL has been observed in the targeted investigations described above. If DNAPL is present at the site, it is likely present in small pockets that would defy practical discovery and delineation efforts.

The configuration of the north CVOC plume suggests a potential source of ongoing CVOC loading. The major axis of this oval plume is roughly coincident with the industrial sewer line that conveyed wastewater from the Roundhouse and Machine Shop to the Wastewater Treatment Plant in AOI-34, suggesting the possible presence of CVOC-containing sludge in the line. The main trunk line of the sewer is constructed of vitrified clay pipe (Appendix C). The materials of construction, the sewer's age (constructed in the 1960's), and the open surface drains may result in some potential for ongoing release of CVOCs from the sewer to the environment.

PLUME IMPACTS TO SURFACE WATER BODIES

Based on the available data, impacted groundwater from the south or north plumes does not appear to be discharging to the Weber River. This finding is consistent with the understanding of site groundwater described above, which indicates that Weber River is a losing stream in the vicinity of the site. Additionally, if CVOCs did discharge to the river, they would be readily attenuated through dilution, volatilization, and biodegradation.

The City of Ogden storm sewer line that crosses the site in an east-west direction and discharges into the Weber River was sampled. Sampling of the storm sewer revealed low concentrations of vinyl chloride that apparently is the result of impacted groundwater leaking into the sewer. However, site data suggest a very low mass flux of CVOCs to the river, as CVOCs have not been detected in Weber River surface water samples, including samples collected at the down-stream end of the rail yard. The non-detection of CVOCs in the Weber River is due to attenuation through dilution, volatilization, and biodegradation.

1.2.3.2 Northern Area

DNAPL

A DNAPL apparently associated with historic Pintsch Gas Facility production occurs over an area of approximately 12.5 acres, extending northwest from the location of the former Pintsch Gas facility (area of 33-MW2FP on Figure 1-5). The material was initially identified as a DNAPL because it occurs beneath the local water table and pools or accumulates in depressions on the clay surface. This has been verified through collection and analysis of the nonaqueous phase liquids. The DNAPL zone extends beneath an approximate 400-foot long stretch of the Ogden River and into the southeast corner of the 21st Street Pond. (In general, the pre-21st Street Pond borrow pit was excavated to the top of the Alpine Clay. DNAPL encountered in the pond occurs immediately above the Alpine Clay.)

The lateral extent of residual phase DNAPL is shown in Figures 1-5 and 1-7. Residual DNAPL occurrences generally show a reddish translucence and are highly aromatic. The residual DNAPL appears to be the non-wetting fluid, based on the fact that it is easily washed from the rounded gravels when submerged in water in the field. Where the DNAPL exists at sufficient saturations to be potentially recoverable, the DNAPL is generally dark brown in color. However, under current conditions, the potential for further lateral migration of the DNAPL appears to be limited.

The DNAPL extent was further evaluated in September 2003, with the completion of 34 additional borings. The details of this additional DNAPL delineation are summarized in Appendix D. In summary, four depressions described below were identified on the Alpine clay surface which could contain pools of potentially recoverable DNAPL. None of these pools have direct connections to the 21st Street Pond.

1. The area represented by well 33-MW1FP is the largest defined depression. Over 1,400 gallons of DNAPL were pumped from this location during the pilot DNAPL recovery test (Forrester Group, 2003d). The 33-MW1FP well still contains 1.6 feet of DNAPL.

2. A smaller depression is in the vicinity of well 33-MW2FP. Four hundred gallons of DNAPL were recovered from this location during the pilot DNAPL recovery test, and the DNAPL remains depleted in this well. However, results of the September 2003 boring program identified a depression 2.4 feet deeper that the 33-MW2FP location, located 75 feet north west of 33-MW2FP.

3. A small depression is present at the northern end of the DNAPL zone, represented by well 33-MW4FP and boring 33-B113. This area has limited potential for recovery as well 33-MW4FP does not have a measurable accumulation of DNAPL.

4. The smallest depression is located just east of the 21st Street Pond and is represented by 33-MW5FP. Less than one foot of DNAPL is present in the well.

Results of physical parameters analyses of the DNAPL are summarized below:

- Interfacial Tension: 34.00 to 39.75 dynes/cm

- Specific Gravity: 1.0043 to 1.0474 g/ml

- Kinematic Viscosity: 16.97 to 19.61 cSt

Chemical composition of the DNAPL was determined from analysis of gravel samples with high levels of DNAPL contamination. Various PAHs were detected in the DNAPL. VOCs detected in the samples are limited to benzene, toluene, ethylbenzene, and xylene ("BTEX") and styrene. PCBs were not detected in the DNAPL.

The analytical data for the contaminated soil samples were compared to the site-specific screening level values (SLVs) established for human-health risk assessment. Based on this comparison, arsenic and the following PAHs exceeded the SLVs in at least one of the samples: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene. Total petroleum hydrocarbons were also detected above the SLVs; however, VOCs including the detected BTEX compound concentrations were all below the SLVs. Based on this comparison, the primary COCs are PAHs.

A sample of the NAPL-impacted soil was also analyzed using a modified 8015 Simulated Distillation analysis. Based on the analysis, it was concluded that the DNAPL is not a creosote or refined petroleum product. Instead, it is most likely a residue from a pyrogenic source, similar to a manufactured gas operation.

21ST POND SEDIMENT AND SURFACE WATER

The DNAPL zone extends into the southeastern corner of the 21st Street Pond. Sediments in the southeast corner of the 21st Street Pond have been impacted with DNAPL since the pond was constructed in 1973. The Utah DOT reportedly encountered DNAPL during excavation of gravels from the southeast corner of the pond.

Sediment sampling has established that the DNAPL-impacted sediments are limited to an approximate one-quarter acre area of the approximate 25-acre pond. Pond sediment and surface water sampling results have shown that DNAPL constituents are present at low levels in sediments in the areas of the pond outside the relatively small zone of DNAPL-impacted sediments.

In response to the presence of DNAPL-impacted sediments in the pond, EPA collected fish samples from the Pond for chemical analyses to determine if fish were being impacted. PAHs (the predominant class of constituents in the DNAPL) generally were not detected in any of the fish samples. This finding is consistent with the technical literature on the subject, which indicates that PAHs are rapidly eliminated from fish and do not generally pose a threat to fishery resources.

OGDEN RIVER

The stretch of Ogden River from upstream of the mainline trestle to downstream of the 21st Street Pond outlet was thoroughly examined. No evidence of migration of DNAPL into the river (for example, oily river sediments containing PAHs) was observed. A variety of PAHs were detected in Ogden River sediments, the most common ones being fluoranthene and pyrene. These PAHs were found at similar frequencies and concentrations in all stretches of the Ogden River, regardless of whether the samples were upstream, overlying, or downstream of the projected DNAPL zone. This indicates that these PAHs may result from a number of different sources. For example, PAHs are a common constituent in urban-area runoff. It is possible that the DNAPL zone could be the source of PAHs detected in the Ogden River sediments, but no mechanism of DNAPL release to the River has been established through the investigations performed to date.

GROUNDWATER

With the westward groundwater flow direction in the area, the DNAPL zone has the potential to impact groundwater. As a measure of the worst-case level of dissolved DNAPL-related constituents in the groundwater, four samples of groundwater were collected from four wells located in an area of potentially recoverable DNAPL. Benzene, ethylbenzene, and PAHs were the predominant constituents detected in the groundwater samples above site groundwater screening levels. In general, benzene is the constituent that exceeded its screening level most frequently and with the greatest degree. The extent of benzene groundwater impacts appears to be limited to within a few hundred feet outside the DNAPL zone.

1.2.4 Contaminant Fate and Transport

1.2.4.1 Rail Yard

The best insight that can be drawn regarding the potential future extent of the LNAPL and CVOC plumes is from their current extent. Data derived from plume extent, the presence of degradation products, and groundwater geochemistry combine to produce a compelling case that intrinsic bioremediation is a significant factor in aqueous phase CVOC transport.

Monitoring data indicate both the north and south LNAPL pools may have reached their steady-state extent. The LNAPL in the southern area, in particular, is thought to be predominantly comprised of LNAPL that has reached a residual saturation (immobile as LNAPL). Given the distance of the LNAPL zones to surface water bodies, LNAPL migration into the Weber River or 21st Street Pond is not considered likely.

Based on the groundwater sampling data, it appears that intrinsic bioremediation is occurring at a rate sufficient to prevent significant expansion of the CVOC plumes. In fact, examination of "concentration versus time" data for key monitoring wells suggests that the south CVOC plume may actually be shrinking, while the north plume appears to have reached a steady-state extent. The results of continued monitoring of key wells (recommended from the RI Report) are discussed in Appendix E.

NORTH PLUME

The vinyl chloride found in the north plume is likely the product of reductive dechlorination of perchloroethylene ("PCE"), trichloroethylene ("TCE"), and 1,1,1-trichloroethane ("1,1,1-TCA") (see Appendix B). The effect of adsorption on retarding vinyl chloride transport is very low because vinyl chloride does not strongly adsorb to organic material, and therefore vinyl chloride migrates at essentially the same rate as the groundwater seepage velocity (calculated to be 5.7 ft/day). Based on the rate of groundwater transport and that any release of chlorinated solvents likely occurred long ago, the plume should extend much further than it does if attenuation (including biodegradation) is not occurring (see Part 1 of the RI Report for more details on plume attenuation calculations (Forrester Group, 2003a)).

Geochemical sampling indicates that redox conditions in the north plume are at least sulfate-reducing. The biodegradation of the diesel LNAPL is likely driving the redox levels to this range, as LNAPL biodegradation would quickly consume dissolved oxygen and nitrates, convert ferrous iron to ferric iron, and result in the sulfate-reducing conditions required to dechlorinate vinyl chloride and its parent compounds. The protocol specified in the *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater* (USEPA, 1998) was used to evaluate the probability of biodegradation of chlorinated solvents in the northern CVOC plume. Based on data from the northern vinyl chloride plume, the protocol indicated "adequate evidence" for anaerobic biodegradation of chlorinated organics is occurring. A range of first-order vinyl chloride decay rates and half-lives was calculated based on a one-dimensional model, and the most reasonably expected range of derived vinyl chloride half-lives was 12-62 days. The most significant aspect of the modeling was that over the wide range of conditions tested, vinyl chloride removal was required to explain the observed plume configuration. Additional sampling performed for the Feasibility Study detected methane, ethene, and ethane; this indicates that vinyl chloride is being reduced to ethene and that there is strong evidence for reductive dechlorination.

The natural attenuation modeling analysis provided in Appendix B provides a more detailed evaluation supporting this conclusion.

As stated previously, the north plume appears to be at a steady-state extent. However, should the plume expand further to the north, it would discharge into the 21st Street Pond, which serves as a groundwater sink along its southern edge. Thus, impacts to down-gradient off-site locations where the alluvial groundwater could potentially be used as a source of water supply do not appear plausible. If the plume did enter either the 21st Street Pond or the Weber River, dilution would considerably reduce the vinyl chloride concentration. Also, vinyl chloride would quickly bioattenuate because both receptors are aerobic bodies of water and vinyl chloride is very amenable to aerobic biodegradation. Furthermore, vinyl chloride is a volatile chemical that would escape from surface water to the atmosphere where it could be rapidly destroyed by photo-oxidation. Therefore it is quite probable that these attenuation mechanisms would prevent vinyl chloride from exceeding surface water bench mark concentrations. The alternate concentration limits ("ACLs") analysis provided in Appendix F provides a more detailed evaluation supporting this conclusion.

SOUTH PLUME

The south vinyl chloride plume is most likely the result of attenuation processes that have reductively dechlorinated TCE and its daughter products. Like the north plume, the extent of the south plume would be much further downgradient if the plume was not being attenuated. Diesel LNAPL over the south plume is likely driving the redox condition to sulfate-reducing or methanogenic conditions, which are required for reductive dechlorination of TCE to vinyl chloride.

Site data indicate that the south plume is not expanding; in fact, examination of "concentration versus time" data for key monitoring wells suggests that the south CVOC plume may actually be shrinking. This suggests that the original release of TCE to the environment occurred long enough ago that very little is left, as indicated by limited detections of TCE in one upgradient well ("21-MW2"). To confirm that additional potential source areas did not exist upgradient (south) of this well, an additional Geoprobe groundwater sampling investigation was performed upgradient of 21-MW2 as part of the Feasibility Study. No potential source areas were found.

The natural attenuation analysis provided in Appendix E and the RI Report provides a more detailed evaluation supporting this conclusion.

The Weber River is the primary surface water body in the area near the south plume. Several monitoring wells between the downgradient extend of the plume and water samples taken from the Weber River have not detected vinyl chloride. Additionally, the direction of groundwater flow in this area is toward the north/northwest, and is not immediately toward the Weber River. Therefore, the south plume appears to be contained to the rail yard and does not appear to be impacting the Weber River.

1.2.4.2 Northern Area

Depending on the specific constituent of the hydrocarbon DNAPL, important fate processes for these constituents in surface water include photolysis, aerobic biodegradation, volatilization, and bioaccumulation. Volatilization will be an important fate process for the monoaromatic constituents of the DNAPL. Aerobic biodegradation and photolysis can be important fate processes for aqueous phase PAHs. In surface waters, higher-ringed PAHs will accumulate in sediments. PAHs do not tend to accumulate in fish tissues, and are not generally a threat to fishery' resources.

PAHs are the primary class of constituents of concern in the Northern Area hydrocarbon DNAPL. The solubility of individual PAHs generally decreases with increasing number of rings and molecular weight. Water in equilibrium with materials similar to the DNAPL present at the Ogden rail yard site generally does not contain higher-ringed PAHs in the aqueous phase. PAHs that will partition into groundwater at the highest concentrations are also those PAHs that are most readily biodegradable. While the lower-ringed PAHs biodegrade under both aerobic and anaerobic conditions, the higher-ringed PAHs are generally biodegraded only under aerobic conditions.

DNAPL

A portion of the DNAPL at select locations is potentially mobile, and there exists an associated potential for future DNAPL migration. Given the decades that the DNAPL has existed, it is reasonable to assume that it has achieved at least a pseudo steady-state extent. However, a common characteristic of "steady-state" DNAPL plumes is that they tend to exist at a state of incipient motion, in which physical or hydraulic disturbances could cause the DNAPL to seek a new equilibrium that could result in further spread or retreat of the DNAPL.

All available data indicates that the low permeability Alpine Formation is an effective barrier to further vertical (downward) DNAPL migration. If DNAPL was to migrate, it would travel laterally, as discussed below. Although based on the site data, it is believed that the remaining accumulations of potentially mobile DNAPL are confined to "structural" depressions in the surface of the Alpine clay.

The excavation of the 21st Street Pond in 1973 probably caused redistribution and lateral spread of the DNAPL zone that existed up to that time. Despite the long period that has passed since this event (approximately 30 years), the DNAPL extent within the excavation (21st Street Pond) is limited to a distance of approximately 100 feet from the edge of the excavation. This suggests the DNAPL zone poses limited potential for future lateral migration in the 21st Street Pond, in the absence of further disturbances (Appendix D).

GROUNDWATER

With the westward groundwater flow direction in the area, the DNAPL zone has the potential to impact groundwater. DNAPL constituents that were detected in groundwater are believed to be localized to groundwater above the DNAPL (Figure 1-7). As long as the DNAPL is in contact with groundwater, there will be some ongoing loading of DNAPL constituents to the groundwater as a result of DNAPL/water partitioning. The groundwater flowpath is toward the 21st Street Pond (Figure 1-5).

Upon discharge of this impacted groundwater to the 21st Street Pond, a variety of attenuation mechanisms act to reduce the concentrations of the aqueous phase DNAPL constituents. These attenuation mechanisms include dilution, volatilization, photolysis, and biodegradation. For the PAHs that are the primary constituents of concern in the DNAPL, photolysis and aerobic biodegradation are important fate processes. Based on estimated concentrations of aqueous phase PAHs discharged into the 21st Street Pond and their predicted attenuation rates, it is very unlikely that groundwater discharge from the DNAPL zone is sufficient to result in detectable concentrations of PAHs in the bulk of the 21st Street Pond surface water. The ACL analysis provided in Appendix F provides a more detailed evaluation supporting this conclusion.

POND SEDIMENTS AND SURFACE WATER

While there are a variety of mechanisms by which constituent loading to the 21st Street Pond is occurring or could potentially occur, with respect to PAHs, the most significant factor is the historic seepage of DNAPL into the southeast corner of the pond. PAHs have been detected in 21st Street Pond surface water samples collected immediately above the DNAPL-impacted sediments in the southeastern corner of the pond. However, no PAHs have been detected in the other 21st Street Pond surface water samples.

There is no evidence that the DNAPL pool, either directly or indirectly through discharge via the 21st Street Pond, has impacted Ogden River sediment or water quality. No DNAPL constituents of concern have been detected in Ogden River surface water samples. Fluoranthene and pyrene have been detected in Ogden River sediments at similar frequencies and concentrations both upstream and downstream of the DNAPL pool. PAHs are common constituents of urban runoff.

1.2.5 Baseline Risk Assessment

Baseline Human Health and Ecological Risk Assessments were completed by EPA in January 2003. Both risk assessments addressed risks from contaminants in sediments, surface water, soils, groundwater, and soil gas present on the rail yard site and nearby surrounding areas. For many media, the risk assessments concluded that exposure is not likely to be of health concern, with the exception of exposure to groundwater as discussed below in section 1.2.5.1. Additionally, the risk estimates derived in the risk assessments more likely to overestimate than underestimate risk. Herein, the discussion of risk is limited to impacted media that are believed to possibly pose an elevated risk.

1.2.5.1 Baseline Human Health Risk Assessment

RISK ESTIMATES FOR ON-YARD WORKERS

For soil, the Baseline Human Health Risk Assessment concluded that non-cancer risk is generally not elevated above acceptable levels (HI=1), with the exception of AOI-21, where the risk level is slightly higher (HI=2). The non-cancer risk at this location is mainly due to the ingestion of arsenic in surface soil. Cancer risk from soil was mainly within or below EPA's risk range, except for RME workers at AOI-21 and AOI-27. At AOI-27, cancer risk may reach a level of 2 in 10,000, mainly due to arsenic. At AOI-27, cancer risk may reach 7 in 10,000, mainly due to PAHs (especially benzo(a)pyrene).

The Baseline Human Health Risk Assessment concluded that groundwater beneath several areas of the site would pose a substantial risk to workers from direct ingestion and inhalation of VOCs if it were ever used for drinking or other indoor purposes. Non-cancer ingestion-risk drivers varied, with most risk coming from vinyl chloride, arsenic, antimony, naphthalene, benzene, trichloroethylene, or acetone. Non-cancer inhalation-risk was due mainly to naphthalene and 1,2-dichloroethlene. For both ingestion and inhalation, the excess cancer risk was due primarily to vinyl chloride.

RISK ESTIMATES FOR OFF-YARD RESIDENTS

The Baseline Human Health Risk Assessment concluded that if on-site groundwater were to migrate to off-site locations and be used for drinking, risks to residents would be unacceptable in many cases, with risks even higher than to on-yard workers. This is because water ingestion rates and time spent inside are both higher for residents than workers.

Risk from soil gas intrusion was not evaluated quantitatively in the Baseline Human Health Risk Assessment. Based on the finding that risks to on-yard workers from soil gas intrusion into current or future on-yard buildings are within or below EPA's risk range, it is considered likely that risks from soil gas intrusion at off-site locations are also low. Further studies were conducted to more fully assess this potential off-site exposure pathway, and these results are provided in the Vapor Phase Investigation Report (FG, 2003b). Based on the Vapor Phase Investigation, it has been concluded that this pathway does not pose risks above acceptable levels.

RISK ESTIMATES FOR OFF-YARD RECREATIONAL VISITORS

The results of the Baseline Human Health Risk Assessment suggest that ingestion of fish caught within the 21st Street Pond might be of potential health concern to fishermen because of non-cancer risks from PCBs. Cancer risks are within or below EPA's acceptable risk range. Based on the investigations conducted to date, there is no evidence indicating the UPRR rail yard is the source of the PCBs.

Risks from non-PCBs in fish from the 21st Street Pond do not exceed EPA's risk range for cancer or non-cancer effects.

1.2.5.2 Baseline Ecological Risk Assessment

RISKS TO AQUATIC RECEPTORS

The Baseline Ecological Risk Assessment concluded that the weight of evidence combined across all observations indicates that risks to aquatic receptors from site-related chemicals are not of concern, except possibly for risks to benthic organisms from xylenes, PCBs, and PAHs in the east end of the 21st Street Pond and PCBs in the Ogden River upstream of the 21st Street Pond outfall to Wall Avenue. Based on the investigations conducted to date, there is no evidence indicating the UPRR rail yard is the source of the PCBs in either the Ogden River or the 21st Street Pond.

RISKS TO WILDLIFE RECEPTORS

No significant risk attributable to UPRR operations to wildlife receptors was present. Risks to semi-aquatic wildlife receptors (kingfisher, mallard, mink) may be significant for individuals that ingest PCBs in aquatic prey from the 21st Street Pond and/or from the Ogden River near the pond.

2 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

Identification and screening of technologies is the link between the remedial investigation and development of remedial action alternatives to address specific operable units at the site (Northern Area and Ogden Rail Yard Groundwater) as a whole. This link is accomplished by first developing remedial action objectives and then by identifying and screening specific remedial action technologies that may be used to meet these objectives for specific chemicals of concern and media.

2.1 REMEDIAL ACTION OBJECTIVES

This section presents Remedial Action Objectives ("RAOs") for the Ogden Rail Yard Site as required by Section VIII, Paragraph 37 e (1) of the administrative order and as approved by EPA on May 16, 2003. RAOs are presented for the two Operable Units ("OUs") that are addressed in the Feasibility Study.

2.1.1 Northern Area

RAOs for the Northern Area OU ("OU-01") are as follows:

1. Protect human and ecological receptors from exposure to DNAPL contaminated sediments at the 21st Street Pond.

2. Prevent unacceptable exposure risk to current and future human populations presented by direct contact, inhalation, or ingestion of contaminated groundwater.

3. Prevent potential future groundwater plume migration as necessary to protect current beneficial uses and potential beneficial uses of groundwater in the vicinity of the site, and to be protective of surface waters and their designated uses.

4. Restore the groundwater to beneficial uses (as technically practicable).

5. Treat, contain, or remove DNAPL to prevent or minimize further spread of the DNAPL.

2.1.2 Rail Yard Groundwater

RAOs for the Rail Yard Groundwater OU ("OU-04") are as follows:

1. Prevent unacceptable exposure risk to current and future human populations presented by direct contact, inhalation, or ingestion of contaminated groundwater.

2. Prevent potential future groundwater plume migration as necessary to protect current beneficial uses and potential beneficial uses of groundwater in the vicinity of the site, and to be protective of surface waters and their designated uses.

3. Restore the groundwater to beneficial uses (as technically practicable).

4. Treat, contain, or remove sources of ongoing contaminant loading to the groundwater plumes.[1]

2.2 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

An initial selection of technologies which appear to be the most likely candidates for implementation at the Ogden Rail yard site was completed (Appendix A). Based on this initial screening and the RAOs discussed above, the list of remedial alternatives that would undergo detailed evaluation was developed in a series of work sessions and discussions among UPRR, EPA, and the Utah DEQ.

[1] The specific "hot spots" that will be addressed in the FS pursuant to this RAO are: 1) the former industrial wastewater sewer line (and underlying soils) overlying the Northern Plume and other potential sources, and 2) the zones of highest VOC concentrations in both the Northern Plume and Southern Plume.

3 DEVELOPMENT OF ALTERNATIVES – NORTHERN AREA OPERABLE UNIT

Remedial Action alternatives to be evaluated for the Northern Area OU ("OU-01") are as follows:

1. No Further Action.

2. Interim actions implemented to date with Monitored Natural Attenuation and institutional controls. Actions implemented to date include the fence around the DNAPL-impacted sediments, pond water level management, and limited DNAPL recovery. Additional groundwater sampling would be conducted to monitor DNAPL-related contaminant levels in groundwater.

3. Pond sediment containment remedy with DNAPL recovery and institutional controls. Screening and refinement of the pond sediment remedies previously presented in the Focused Feasibility Study was performed to identify the preferred remedy for the DNAPL-impacted sediments in the 21st Street Pond.[2] A DNAPL recovery alternative based on the results of the DNAPL recovery pilot test and the additional DNAPL zone characterization work was developed. This alternative focuses on application of the dual phase recovery method (the technology successfully used in the pilot test) in stratigraphic lows where continuous phase DNAPL exists in the greatest quantities. Additional groundwater sampling will be conducted to monitor DNAPL-related contaminant levels in groundwater.

4. Pond sediment excavation remedy with intensive DNAPL zone treatment and institutional controls. This alternative incorporates a more intensive DNAPL zone treatment approach that maximizes reduction of contaminant mobility, volume, and toxicity with the goal of full restoration of beneficial use. The specific treatment approach that was incorporated into the alternative is dynamic underground stripping (a steam technology).

[2] Focused Feasibility Study for Interim Remedial Action, Ogden Rail Yard, 21st Street Pond, Ogden, Utah (*DRAFT*), September 21, 2001, The Forrester Group, Chesterfield, MO. This document was submitted to the regulatory agencies for information purposes only. This document has not been reviewed or approved by the regulatory agencies.

5. Pond sediment excavation remedy with DNAPL recovery and institutional controls. This alternative incorporates removal of the impacted sediments from the 21st Street Pond as described in Alternative 4, and the DNAPL recovery described in Alternative 3.

3.1 Alternative 1 – No Further Action

This alternative serves as the baseline for comparison of other alternatives. With this alternative, no monitoring, control, or treatment of impacted media is performed.

3.2 Alternative 2 – Interim Actions Implemented to Date with Monitoring

This alternative focuses on the benefits of the interim actions implemented to date combined with continued monitoring to demonstrate whether future conditions can achieve the remedial action objectives.

3.2.1 Concept

This alternative includes two components:

- Interim actions implemented to date. These include the fence around the DNAPL-impacted sediments, pond water level management, and limited DNAPL recovery.

- Groundwater monitoring. Additional sampling would be conducted to monitor DNAPL-related contaminant levels in groundwater. Data would be used to determine shifts in the groundwater plume and/or DNAPL zone. The results of the monitoring work would be used to confirm that the risk of exposure is acceptable.

3.2.2 Conceptual Design

3.2.2.1 Interim actions implemented to date

This part of this design includes maintenance of the following interim actions.

- Maintaining the chain link fence that completely encircles the DNAPL-impacted pond bottom materials and the bank on the SE corner of the pond, to prevent both human and larger mammalian ecological receptors (for example, beaver) from contacting the DNAPL-impacted pond bottom materials.

- Maintaining the fish guard at the pond inlet to prevent fish from entering the pond from the Ogden River.

- Maintaining the elevated pond water levels to minimize nesting areas, and reduce the potential for direct exposure of birds to DNAPL-impacted pond bottom materials by increasing the distance between the water surface and pond bottom sediments.

During the DNAPL recovery pilot test, over 1,850 gallons of DNAPL were recovered. The recovered DNAPL was sent to a permitted oil recycling facility. The recovery of this DNAPL has reduced the amount of continuous phase DNAPL.

3.2.2.2 Groundwater monitoring

Future groundwater monitoring would be used to evaluate the extent of dissolved phase contaminates in groundwater and extent of DNAPL. At equilibrium, DNAPL zones reach some steady-state extent at which DNAPL migration stops unless hydraulically perturbed. Based on several years of groundwater and DNAPL monitoring, as well as calculations, the DNAPL zone has reached its steady state extent and future migration is not anticipated under current conditions (Forrester Group, 2003a, Part 2 Appendix K). Monitoring data also indicate that the extent of dissolved contaminants in groundwater is limited to within a few hundred feet of the edge of the DNAPL zone. These data would be used to confirm that interim actions implemented to date are sufficient to preclude human exposure to the DNAPL, DNAPL impacted pond sediments, and DNAPL-impacted groundwater.

The Northern Area groundwater monitoring network includes 16 monitoring wells located either in the down gradient portion of the DNAPL zone or just beyond it. The aerial distribution of these wells to the DNAPL zone is shown in Figure 3-1. Groundwater monitoring would take place on a semi-annual basis (in May and August/September). Groundwater and DNAPL gauging would be used to estimate groundwater flow direction and to determine whether DNAPL thicknesses are significantly changing over time. Groundwater samples would be analyzed for the chemicals that compose the DNAPL, VOCs (benzene and ethylbenzene) and SVOCs (PAHs).

(A list of wells and analytical methods is provided in Table 3-1). Data would be analyzed both spatially and over time (that is, concentration vs. time and concentration versus distance) to determine what trends (if any) are apparent.

3.2.3 Cost Estimate

Because the interim actions have already been implemented, the main costs associated with this alternative are costs associated with monitoring and reporting. The estimated cost (present value) of these activities, for a period of 30 years is $500,000.

3.3 Alternative 3 – Pond Sediment Remedy with DNAPL Recovery and Institutional Controls

This alternative employs active future remedial actions to contain and recover DNAPL. Remedial actions focus on minimizing the potential for exposure to or migration of DNAPL within the 21st Street Pond and recovery of continuous phase DNAPL to the extent practical, using an innovative DNAPL recovery system.

3.3.1 Concept

3.3.1.1 Pond Sediment Remedy

Alternative 3 addresses the risk posed by the DNAPL-impacted pond bottom materials by containing and capping the DNAPL-impacted pond bottom materials in place. Major components of this alternative are briefly described as follows:

- A cofferdam will be constructed to segregate the DNAPL-impacted corner of the pond from the remainder of the pond.
- The DNAPL-impacted corner of the pond will be backfilled and capped.
- A series of monitoring wells will be installed in the identified flow path of the DNAPL plume extending into the pond (Figure 3-2), to monitor for future migration of DNAPL. In the event that DNAPL becomes detected, these wells will serve as recovery wells.

Alternatives 3, 4, and 5 employ a barrier system to preserve existing groundwater flow paths to the extent practical and thus minimize hydraulic perturbations of the DNAPL zone east (upgradient) of the pond. These alternatives allow the discharge of the groundwater from the DNAPL zone into the pond to continue.

The pond sediment remedy for Alternative 3 is illustrated in Figures 3-2 and 3-3. Each major component of Alternative 3 is described in more detail in the following text. The construction time needed to implement the pond sediment remedy portion of Alternative 3 is estimated to be 16 weeks.

3.3.1.2 DNAPL Recovery

Based on the results of the RI and FS investigations, the DNAPL zone has been well defined within the area of AOI-33. Initial DNAPL zone delineation was completed through field observation and analysis of core retrieved from borings and monitoring well installations. In September, 2003, 34 additional borings were completed within the DNAPL zone to refine the estimate of zones where recoverable DNAPL occurs. (Recoverable DNAPL is defined as DNAPL that occurs as a continuous phase that can readily flow to a well or drain). The results of the boring completions, observations of DNAPL-saturated core, and results of the pilot DNAPL recovery testing show that there are two identified depressions on the top of the Alpine clay surface that have accumulations of potentially recoverable DNAPL (Figure 3-4), and two depressions that may contain potentially recoverable DNAPL accumulations. In the remaining areas of the DNAPL zone, the configuration of the clay surface gently slopes toward the North-Northwest. DNAPL in these areas occurs as discontinuous blobs and ganglia (residual saturation that will not flow freely to wells or drains).

Additional recovery of DNAPL from each of two identified pools located around 33-MW1FP and east of 33-MW5FP (Figure 3-5) will be accomplished through application of the pumping recovery mechanism proven during the 2002 pilot DNAPL recovery project (Forrester Group, 2003d). This recovery system involves recovery of both groundwater and DNAPL through two separate pump strings in a recovery well. The pumped water is treated with granular activated carbon ("GAC") and injected into the formation at a point upgradient of the recovery well. Injection of the recovered groundwater enables a higher pumping rate of groundwater, which in turn accentuates groundwater flow to the recovery wells and also enhances DNAPL migration to the well.

The pool in the vicinity of 33-MW1FP is about 150 feet in diameter. Wells completed in the center of this pool have about 1.6 feet of measurable DNAPL (1,450 gallons of DNAPL were previously recovered from this area in the Pilot recovery test). The recovery system will resume operation in this area to extract the remaining recoverable DNAPL. A decline curve analysis will be used to resolve the practical endpoint of DNAPL recovery (Sale, 2001). An additional recovery well may be installed in the eastern portion of the depression if necessary.

The pool in the vicinity of 33-MW5FP is limited to about 50 feet in diameter. Measurable DNAPL in well 33-MW5FP is less than one foot. Based on the size of this pool as currently defined, the amount of recoverable DNAPL is probably limited.

Two additional depressions that may contain accumulations of potentially recoverable DNAPL are represented by the areas near 33-MW2FP and 33-MW4FP. At the 33-MW2FP location, over 400 gallons of DNAPL were recovered during the pilot test, and wells in this area still remain depleted. However, a deeper depression was identified just to the northwest of this well by boring 33-B91. An additional well will be completed in this depression, estimated to be 60 feet in diameter. The second depression that may contain potentially recoverable DNAPL is in the vicinity of 33-MW4FP, about 70 feet in diameter. A recently completed boring east of 33-MW4FP shows about 1.5 feet of DNAPL saturated gravels, although the 33-MW4FP well in the west edge of this same depression does not contain measurable DNAPL. An additional well will be completed between 33-MW4FP and boring 33-B113. If justified by significant accumulation of measurable DNAPL, then recovery will be attempted.[3]

Starting with 33-MW1FP, the recovery system will be moved and operated in each area until the DNAPL is depleted to the extent practicable as indicated by a decline curve analysis (Sale, 2001). UPRR anticipates that the recovered DNAPL will be processed at a permitted oil recycling facility as it was during the pilot test. Post-recovery monitoring will be conducted in the areas to monitor the effectiveness of the recovery and to check for additional DNAPL accumulation.

[3] The relationship between DNAPL in a well and DNAPL in a formation is complex. As such, DNAPL in a well will not always correlate to recoverable DNAPL in the formation.

Periodic monitoring since the end of the pilot test shows that measurable DNAPL has not returned to the 33-MW2FP area wells.

The amount of potentially mobile DNAPL remaining is estimated to be between 1,860 and 35,300 gallons. This estimate is based on the amount of DNAPL recovered from the pilot testing (1,860 gallons), as representing 50% to 5% of the recoverable DNAPL at the site.

3.3.1.3 Institutional Controls

Institutional controls include access restrictions and monitoring to prevent human exposure to contaminate media. The mechanism of the institutional controls could include deed notices, deed restrictions, and/or restrictive covenants. A new section of the Utah Environmental Quality Code (Environmental Institutional Control Act Utah Code Sections 19-10-101) signed into laws in 2003, provides a mechanism to make and impose institutional controls upon subject properties Further examples of these institutional controls are provided in Appendix G.

The Northern Area groundwater monitoring network includes 16 monitoring wells located either in the DNAPL zone or just beyond it. The aerial distribution of these wells to the DNAPL zone is shown in Figure 3-1. Groundwater monitoring would take place on a semi-annual basis (in May and August/September). Groundwater and DNAPL gauging would be used to estimate groundwater flow direction to determine whether DNAPL thicknesses are significantly changing over time. Groundwater samples would be analyzed for the chemicals that compose the DNAPL, VOCs (benzene and ethylbenzene) and SVOCs (PAHs). (A list of wells and analytical methods is provided in Table 3-1). Data would be analyzed both spatially and over time (that is, concentration vs. time and concentration versus distance) to determine what trends (if any) are apparent. Groundwater restoration will be achieved when site groundwater concentrations are below MCLs for four consecutive monitoring events.

3.3.2 Conceptual Design

3.3.2.1 Pond Sediment Remedy

COFFERDAM

Details of the permanent cofferdam are shown in Figures 3-2 and 3-3. The cofferdam will be constructed with its interior toe approximately aligned at the western edge of the area of potentially impacted pond bottom material, minimizing the area of the pond that will be backfilled.

Excavation of a key trench through the approximately 2 foot thick sediment and gravel layers is needed to tie the cofferdam into the Alpine Formation. The trench will be excavated in the wet with a backhoe, and the excavated material will be relocated east of the cofferdam. Fill material for the cofferdam will be dumped and spread with a bulldozer. The backfill will be advanced across the pond by dumping it underwater until the fill surface is exposed above the water surface.

The fill material used to construct the cofferdam will be a well-graded, silty or clayey sand with some gravel-sized material. This will provide a fill material that will have a low potential for leaving large voids in the fill (especially in the underwater portion where little compaction effort can be applied), while providing low permeability to water and high resistance to entry by DNAPL. This material will be supplemented by an impermeable liner which will be supported by the cofferdam (Figure 3-3). The combination of the liner, horizontal drain, and DNAPL collection sump on the interior of the dam will provide for DNAPL capture and recovery if needed. As shown in Figure 3-3, the maximum fill depth of the cofferdam (at elevation 4,267.0-feet amsl) is expected to be about 5 feet. The depth of water from the pond water surface to the top of the existing gravel layer in the pond bottom is approximately 2.2 feet along the centerline of the cofferdam.

The cofferdam imported fill material will be put in place by dumping and spreading with a bull dozer. As necessary, fill material will be deposited under water until the fill material height is at elevation 4,267.0 feet amsl. The central portion of the fill will be compacted from the surface by truck and backhoe traffic. The outer portions of the fill cannot be compacted, but the fill will have sufficient strength to minimize lateral movement from the point of deposition.

An additional 1 to 1.5 feet of temporary fill material may be placed as needed over the layer of gravel backfill to provide freeboard for the cofferdam during the pond backfill operations. The depth of required freeboard will be approximately 1.5 feet above the water level in the main body of the pond. Any temporary fill material will be removed before the final construction of the cofferdam section is completed, as shown in Figure 3-3. Additional cobbles, graded gravel, and soil fill will be placed over the cofferdam when the final grades are placed during the backfilling of the pond and the dam is incorporated into the backfill area (Figure 3-3). Any fish remaining east of the cofferdam can be relocated to the western portion of the pond using shocking and netting or other techniques.

During the entire period of cofferdam construction and fish relocation, a temporary floating oil control boom will be installed in the pond immediately west of the cofferdam. The temporary oil boom will control the migration of sheens or floating oils beyond the work area, should any be encountered during the construction of the cofferdam.

INSTALL DNAPL DRAIN AND SUMP UPGRADIENT OF THE COFFER DAM

DNAPL drain lines and a sump will be constructed on the upgradient side of the cofferdam, as shown on Figures 3-2 and 3-3. The primary objectives of the DNAPL drain lines and sump is to ensure that DNAPL does not accumulate behind the barrier wall to any appreciable thickness where it could potentially be carried over the cofferdam by groundwater flow. The invert of the drain lines will be located essentially at the top of the Alpine formation and will be sloped to the DNAPL recovery sump, which will be placed at the low point of the Alpine formation along the wall. The drain lines on either side of the sump would convey DNAPL to the sump through gravity flow.

POND BACKFILL AND REVEGETATION

The entire area of the pond east of the cofferdam would be backfilled and vegetated to prevent human, animal, bird, fish, etc. exposure to the underlying DNAPL as shown in Figure 3-3. The backfill would be composed of the following five layers:

- 1st layer: 1-foot layer of gravel (3/4-inch minus). This layer will act as a filter between the cobble layer above and the existing finer sediments below and minimize the penetration of the cobble layer into the sediment layer.

- 2nd layer: Hydrocarbon adsorption buffer zone (1 to 3 inches thick) consisting of highly organic materials such as compost, sawdust, or other oil adsorbent material. This layer is a contingency layer to filter oil sheens should such sheens be released from the underlying DNAPL-impacted zone.

- 3rd layer: Zone of cobbles (2 to 4 inch diameter) to an elevation 1 foot above the top of the overflow weir. The cobble zone will allow groundwater to pass through the back-filled portion of the pond with minimal head loss. This layer will also provide a capillary break to help prevent vertical migration of DNAPL and will discourage borrowing animals from digging beneath the cobble layer.

- 4th layer: 1-foot layer of graded gravel above the zone of cobbles. This layer is size graded to minimize the migration of the overlying soil fill into the cobble zone.

- 5th layer: Fill area above the zone of cobbles. This layer would be a minimum of 2 feet thick (as necessary to provide a 1-foot thickness of unsaturated zone above any mound of groundwater) and would have a minimum of 6 inches of top soil to provide adequate soil depth to support vegetation. The soil fill area will be graded to very gently slope toward the west (0.2 percent) to provide surface drainage toward the pond and then vegetated.

During the backfilling of the pond with the first two layers (graded gravel and cobbles), it is possible that oily sheens may be brought to the surface of the water in portion of the pond contained within the cofferdam. To prevent the migration of the sheens to the main body of the pond during the backfilling operations of layers 1 and 2, no water will be allowed to flow over the cofferdam. The water level in the portion of the pond contained by the cofferdam and barrier wall will be pumped down to elevation 4,266.2 feet amsl (0.8 feet below the top of the weir) or lower if practical. During this period of the backfilling operations, minimizing the water elevation would also aid in more accurate placement of the graded gravel and cobble layers. The temporary oil booms or additional absorbent materials as required will be kept in place until backfilling is complete and any sheens have been managed and removed from the pond.

The thickness of the layers of the engineered containment system (vegetated fill, graded gravel and cobbles), may be altered during the final design to provide flexibility in future land use. Potential future uses for the capped area may include recreational park space, wetlands, or other wildlife habitat. Any future land use must incorporate provisions to allow for long-term access to the DNAPL monitoring sump for monitoring and potential DNAPL recovery (as required).

DEWATERING DURING CONSTRUCTION

An analysis was performed of; 1) dewatering rates and the volume of water generated during dewatering operations, 2) pond hydraulic conditions during remedial construction, and 3) the potential water treatment operations needed for remedial activities at the 21st Street Pond in Ogden, UT.

The pond dewatering analysis used an equation for steady state flow to a pumping well in an unconfined aquifer to estimate the flow rate of water that would be treated in order to maintain pond water levels and to completely dewater it. Then, an estimate of the total volume of treated water was generated using the calculated flow rates and estimates of the working time needed to complete the remedial activities that require dewatering.

Remedial Alternatives 3, 4 and 5 are intended to address the DNAPL-impacted sediments and gravels and prevent future DNAPL migration into the pond. The alternatives include barrier wall designs (coffer dam or sheet pile wall). Installation of a barrier could result in changes in groundwater flow direction and/or increases in hydraulic gradients, which in turn could result in unwanted redistribution of the DNAPL that the barriers are intended to contain. The objective of the modeling was to predict hydraulic impacts of barrier configurations, but not to optimize the barrier configuration, which is a design objective.

Potentially, the least expensive way to treat water would be to acquire a temporary NPDES permit (or equivalent) and discharge to the portion of the pond outside the cofferdam. A preliminary design of a treatment process was further developed in support of estimating capital and operating costs for this method of managing the water.

HYDRAULICS, FLOW RATE AND TREATMENT VOLUME ESTIMATE DURING CONSTRUCTION

For Alternative 3, capping the sediments in place, dewatering would only occur to the extent needed to construct the cap. Key assumptions regarding the flow rate estimates are:

- The water levels in the pond are controlled at the sluice gates to the Ogden River. The lowest water level that can be achieved using only the sluice gates is 4266.5 feet amsl. With either alternative, it is assumed that water levels would be lowered to this level before construction begins.

- For Alternative 3, it is assumed that dewatering would be performed to maintain a water level of 4266.5 feet amsl inside the cofferdam.

- The cofferdam is assumed to prevent pond water from infiltrating back through the cofferdam. Groundwater infiltration into the dewatered area is assumed to be limited to the perimeter of the area that is pond bank.

Based on the dewatering calculations, a dewatering flow rate of 170 gpm would be need to be maintain pond levels at 4266.5 feet amsl. For Alternative 3, dewatering would be needed until the height of the cap is above 4266.5 feet and the cofferdam weir has been constructed such that water can flow over it. The estimated construction time needed to build the cofferdam to the 4266.5 feet amsl is 15 calendar days. Assuming continuous dewatering over the 15 day period, approximately 3 million gallons of water would require treatment.

POND HYDRAULICS AFTER CONSTRUCTION

The details of the hydraulic modeling using MODFLOW were presented in Appendix L of the Remedial Investigation Report (Forrester, 2003a, Part 2) and Appendix C of the Focused Feasibility Study for the 21st Street Pond (Forrester, 2001). Alternative 3 in the Focused FS (Forrester Group, 2001 and in this document uses a barrier installed across the eastern end of the Pond at a cofferdam.

Modeling results for the coffer dam barrier used for Alternative 3 indicate a potential for marginally increased hydraulic gradients at the ends of the barrier, particularly around the southern end. However, these hydraulic conditions should not result in undesired DNAPL migration, based on the following considerations:

- The ends of the cofferdam barrier are outside the projected extend of the DNAPL zone.
- Hydraulic conditions in the area overlying the DNAPL zone should not cause DNAPL migration toward the ends of the cofferdam barrier.
- DNAPL recovery operations, if needed, on the up-gradient side of the cofferdam barrier will further mitigate the potential for DNAPL migration to and accumulation at the ends of the barrier.

In summary, based on similar directions of flow and similar or lesser hydraulic gradients in the area overlying the DNAPL zone, the location of the Alternative 3 barrier and the height of the submerged weir will not effect adverse DNAPL migration.

TREATMENT PROCESSES

The objective of the treatment process would be to remove oil (DNAPL), sediments, and dissolved phase to the extent needed to meet treatment standards. Regardless of whether Alternative 3 or 5 is selected, the approach to treatment would be similar.

Based on the analysis of treatment rates, a 200 gpm operation would be capable of handling the majority of treatment. If "dry" excavation was selected, then some equipment could be duplicated for a short period to provide parallel treatment operations.

Given the short duration of treatment, it is important to keep treatment operations simple, yet effective. Ideally, water treatment operations could be managed by one person or even on a part time basis. Also, 24 hour treatment is needed to maintain dewatered conditions.

Conceptually, the key components of the treatment system are:

1. PUMP. A pump to push water from the area inside the coffer dam into the treatment area and/or back into the pond. A key piece of maintaining cheap and effective treatment is ensuring that the pump intake is maintained at the pond surface to help keep oil and sediments and out of the treatment system. As an additional step, booms could be placed

around the pump intake to prevent oil from being sucked into the pump. Addressing the impacted sediments and dewatering in separate areas of the pond could also help.

2. EQ TANK. The 20,000 gallon equalization tank would receive water from the pump. The purpose of the EQ tank is to allow inspection of the water quality in the treatment system. If the water is of sufficient quality, then water could be directly discharged into the pond from the tank. If further treatment is needed, then water would be sent to a bag filter and carbon system, as described below.

3. BAG FILTER. As needed, bag filters would be used to prevent sediments from fouling the downstream carbon system. Also, if oil droplets escaped the EQ tank, then they could potentially be captured on the filter and/or filter cake. Two units placed in parallel would provide backup capacity during filter change-out. Because the DNAPL is non-hazardous, disposal of the bag filters as a hazardous waste is not anticipated to be an issue.

4. CARBON SYSTEM. Based on the quality of groundwater over the DNAPL and samples collected from pond water, the primary dissolved phase COCs would be benzene and PAHs. The purpose of the carbon system would be to remove these COCs to allowable levels. Carbon vessels would be 1000-2000 lb rented units. If oil can be effectively prevented from reaching the carbon, one large vessel should be sufficient for the project duration (this assumption should be verified with a carbon vendor).

3.3.2.2 Monitoring and DNAPL Recovery

Recoverable DNAPL that accumulates behind the cofferdam will be collected in the sump. The sump will be monitored monthly to detect DNAPL, if any. Because DNAPL accumulation is not expected, no active, permanent DNAPL recovery systems will be installed, but DNAPL may be recovered using a vacuum truck or other recoverable DNAPL pumping system, as needed. If any DNAPL is recovered, it would be processed at a permitted DNAPL recycling facility as it was during the pilot study.

3.3.3 Cost Estimate

As shown in Appendix H, the total cost to implement this alternative is estimated to be $1,607,000.

3.4 Alternative 4 – Pond Sediment Remedy with Intensive DNAPL Zone Treatment and Institutional Control

The focus of this alternative is aggressive and intensive efforts to remove DNAPL from the 21st Street Pond and surrounding areas. The key active technologies that would be employed include excavation and off-site disposal of pond sediments and impacted soil and dynamic underground stripping of DNAPL from DNAPL impacted areas outside the pond.

3.4.1 Concept

3.4.1.1 Pond Sediment Remedy

Alternative 4 addresses the risk posed by DNAPL-impacted pond bottom materials in the 21st Street Pond materials by removing them and disposing them in an off-site disposal facility. Major components of this alternative are briefly described as follows:

- A cofferdam will be installed to hydraulically isolate the DNAPL-impacted pond zone, to enable water level control of this zone and subsequent wet excavation of DNAPL-impacted pond bottom material.

- After the excavation zone has been isolated and water levels controlled, the impacted pond bottom material will be removed and mixed with a stabilizing agent such as cement. The stabilized material will then be transported to a disposal facility.

- The cofferdam will then be removed, and the area where excavation took place will be restored to a physical condition similar to that at the site before construction began.

In Alternatives 3, (involving containment of impacted pond bottom materials) and Alternatives 4 and 5, an objective is to minimize long-term changes in existing groundwater flow paths and hydraulics (particularly increases in hydraulic gradients) to the extent practical. Such changes could result in mobilization of the DNAPL in the area east of the pond, and potentially cause DNAPL to migrate into the pond at other locations. Control of hydraulic conditions over the DNAPL zone through long-term groundwater extraction and treatment operations is undesirable. Therefore, Alternatives 3, 4, and 5 employ a barrier system. The barrier system will be constructed to preclude flow at the base of the alluvium (where the DNAPL exists), and to allow flow in the upper portion of the saturated zone (thus preserving existing groundwater flow paths to the extent practical). Loading rates of aqueous phase DNAPL constituents from the DNAPL zone to the 21st Street Pond have not been sufficient to result in detectable concentrations of DNAPL constituents in pond surface water (except in the DNAPL-impacted corner of the pond). All Alternatives allow the discharge of the groundwater from the DNAPL zone into the pond to continue.

The more aggressive DNAPL recovery under Alternative 4 should eliminate the possibility of any future migration of DNAPL into the remediated section of the 21st Street Pond. With this premise, the barrier system for Alternative 4 will consist of the series of observation/recovery wells used in Alternative 3 (see Section 3.4.2.1 page 3-20, and Figure 3-2). Based on effective removal of the subsurface DNAPL, the more costly barrier wall used in Alternative 5 is not needed.

DNAPL recovery for Alternative 4 is illustrated in Figure 3-6 and 3-7. Each major component of Alternative 4 is described in more detail in the following text. It is estimated that the water management period required for Alternative 4 is approximately 6 weeks (4 weeks for excavation and 2 weeks for backfill of the banks). The total construction time for Alternative 4 is estimated to be approximately 5 months.

3.4.1.2 Intensive DNAPL Zone Treatment

Dynamic Underground Stripping ("DUS") is an innovative thermal remediation technology that accelerates removal of organic compounds, both dissolved phase and DNAPLs, from the subsurface (DOE, 2000). In DUS, steam is injected into the contaminant zone, and energy, in the form of heat, volatilizes contaminants into the vapor phase and solubilizes contaminants into the groundwater (Figure 3-6). In addition, a portion of the contaminant is destroyed in situ by Hydrous Pyrolysis Oxidation ("HPO"), a process that converts contaminants into carbon dioxide and water. Because DUS and HPO occur simultaneously, this technology is frequently referred to as "DUS/HPO".

For the hydrocarbon DNAPL at this site, HPO/DUS relies on a combination of steam and oxygen injection, in situ bioremediation, soil vapor extraction, electrical resistance tomography, and conventional pump and treat technologies.

- Steam and oxygen are injected below the water table to build a heated, oxygenated zone at the periphery of the contaminated area to drive contaminants to centrally located extraction wells.

- HPO/DUS encourages bioremediation by stimulating the growth of microbes that thrive in high temperatures.

- Underground imaging by electrical resistance tomography and temperature monitoring track the steam fronts and heated areas.

- The pump-and-treat component of DUS/HPO provides hydrologic control.

This technology, by operating at high temperatures, takes advantage of the rapid reactions that take place at steam temperature, as well as rapid mass transfer rates, which makes contaminants more available for destruction. When the steam injection is stopped, the steam condenses and the contaminated groundwater is returns to the heated zone. The contaminants in the groundwater mix with the oxygen, condensate, and with the presence of heat, rapidly oxidize. During the initial DUS phase, removal of the contaminants occurs through physical transport to extraction wells with subsequent treatment of effluent vapors, NAPL, and water. Simultaneously and afterwards, HPO treats contaminants in situ.

The overall goal of this technology is that the intensive treatment would remove DNAPL significantly faster and more completely than other technologies (for example, pump and treat). With all or nearly all of the DNAPL treated and removed, groundwater restoration could potentially be achieved. However, based on literature review and discussions with DUS/HPO contractors and EPA staff, groundwater restoration (that is, achievement of MCLs) of DNAPL source areas has not been demonstrated at sites where DUS/HPO has been applied.

Significant insight on the effectiveness of DUS/HPO can be gained from the Visalia Pole Yard Site in Visalia, CA (Appendix I). The Visalia site is impacted by creosote DNAPL, which lays 80-100 feet bgs. The primary groundwater COCs are benzo(a)pyrene, pentachlorophenol, and dioxin isomers. Before DNAPL treatment initiated, a pump-and-treat system was in place to treat the groundwater plume at the facility boundary. Steam injection began in May 1997, and over a three year period approximately 160,000 gallons of DNAPL were removed. MCLs have been achieved at the facility boundary since DNAPL treatment ended in 2001; however, MCLs have not been achieved in the source zone. In fact, restoration of water quality (using DUS/HPO or any other technology) in a DNAPL zone has never been documented.[4] Considering the "lessons learned" from the Visalia Site and the characteristics of the DNAPL zone in the Northern Area of the Ogden Rail Yard:

- Using the DUS/HPO process, near term restoration of groundwater quality (that is, achievement of MCLs) in the DNAPL zone is not certain (and probably will not occur).

- A significant benefit of DNAPL removal at the Visalia Site was achievement of MCLs at the facility boundary after treatment was complete. At the northern area, monitoring well data indicate MCLs are already achieved within a relatively short distance outside the DNAPL zone, and the plume does not appear to be migrating. Although the benefit of achieving MCLs outside the source area does apply to this site, the benefit would be minimal in this case.

- The DNAPL at the Visalia site is much deeper (80-100') than the DNAPL at the Northern Area DNAPL (20'). Also, the Ogden River flows over the Northern Area DNAPL zone and the 21st Street Pond serves as a groundwater sink for DNAPL impacted groundwater. Given the shallow depth of the DNAPL, as well as the proximity and hydraulic connection of the DNAPL to these surface water bodies, the potential for DNAPL migration (due to the decrease viscosity of the DNAPL at high temperatures) and/or higher concentrations of DNAPL constituents in groundwater (due to increased solubility of DNAPL compounds at high temperature) during steam injection is a significant risk. Also, injected steam and "superheated" groundwater would migrate with the groundwater toward these surface waters. Attempts to prevent impacts to these water bodies through engineering controls could be made, but a failure in controls could produce a zone of impact much greater than presently exists.

- The shallow depth of the DNAPL could necessitate 1,000 steam injection and DNAPL extraction wells at the site. The construction of the wells alone would require an

[4] Dr. Tom Sale concluded in his dissertation (Fall 1998) that near term restoration of water quality in a DNAPL zone has never been documented. Based on further conversations (2003) with Dr. Sale, DUS vendors, and EPA personnel, as well as a literature search, no one is aware of a site where MCLs were achieved in the source zone.

enormous construction effort. Because of the constraints caused by existing structures, the 21st Street overpass embankment, and existing mainline tracks over portions of the DNAPL zone, this technology could not be applied to about one-fifth of the DNAPL zone (see Figure 3-7).

3.4.1.3 Institutional Controls

Institutional controls include access restrictions and monitoring. Access restrictions include providing a notice in the site property deed restricting groundwater use and placing covenants on off-site properties restricting groundwater use and well installations. Further discussion of these institutional controls was provided by UPRR in Appendix G.

At the completion of intensive DNAPL recovery efforts, a network of monitoring wells in the DNAPL zone or just beyond it would be sampled (Figure 3-1). Groundwater samples would be analyzed for the chemicals that compose the DNAPL, VOCs (benzene and ethylbenzene) and SVOCs (PAHs). Data would be analyzed both spatially and over time (that is, concentration vs. time and concentration versus distance) to determine what trends (if any) are apparent.

3.4.2 Conceptual Design

3.4.2.1 Pond Sediment Remedy

COFFERDAM CONSTRUCTION

A temporary cofferdam will be constructed in the east end of the pond as shown in Figure 3-2. The purpose of the temporary cofferdam is to isolate impacted material and water in the excavation area from the remainder of the pond during impacted sediment excavation. The cofferdam should be made as watertight as possible. The cofferdam height will be 4,268.0 feet amsl, approximately 1.8 feet above the minimum elevation to which the pond can be dewatered (4,266.2 feet amsl). The depth of water to the top of the Alpine Formation surface at the time of construction is expected to be approximately 2.6 to 3.7 feet along the centerline of the cofferdam. (These depths are based on two pond borings (PB 9 and PB 10) which are along the cofferdam alignment.)

Excavation of a key trench through the approximately 2 feet thick sediment and gravel layers is needed to tie the cofferdam into the Alpine Formation. The trench will be excavated in the wet with a backhoe, and the excavated material will be relocated east of the cofferdam. Fill material for the cofferdam will be dumped and spread with a bulldozer. The backfill will be advanced across the pond by dumping it underwater until the fill surface is exposed above the water surface.

The fill material for the cofferdam will be a well-graded, silty or clayey sand with some gravel-sized material. This will provide a fill material with structural strength and a low potential for leaving voids (especially in the underwater portion where little compaction effort can be applied), while providing low permeability to water and high resistance to entry by sheens and DNAPLs. The maximum fill depth of the temporary cofferdam is expected to be about 5.5 feet (including the key trench). The central portion of the fill will be compacted from the surface by truck and backhoe traffic. The outer portions of the fill cannot be compacted, but by using fill with some gravel content, it will have sufficient strength to minimize lateral flow away from the point of deposition.

A temporary floating oil control boom will be installed in the pond during the entire period of cofferdam construction. The oil control boom will be located immediately to the west of the western edge of the cofferdam (that is, along the temporary fence). This will control the migration of sheens or floating oils beyond the work area, should any be encountered.

INSTALL DNAPL RECOVERY WELLS UPGRADIENT OF THE POND

A series of DNAPL monitoring and recovery wells will be constructed on the upgradient side of the pond in the identified DNAPL flow path (Figure 3-2). The objectives of the DNAPL recovery and monitoring wells are to ensure that DNAPL does not migrate into the remediated sediment area. The wells as shown on Figure 3-2 will be located at the top of the Alpine Formation in the depression on the clay surface that appears to have served as the former migration pathway for DNAPL into the pond. The wells will be monitored on a periodic basis for evidence of DNAPL accumulation. These wells will also serve as extraction points in the event that DNAPL is detected. An additional observation well will be located at the low point in the

Alpine Formation along the wall. This well will be used as an observation well to monitor for any future DNAPL impact of the remediated sediment area.

WATER LEVEL CONTROL DURING EXCAVATION

An analysis was performed of; 1) dewatering rates and the volume of water generated during dewatering operations, 2) pond hydraulic conditions during remedial construction, and 3) the potential water treatment operations needed for remedial activities at the 21st Street Pond in Ogden, UT. The approach for performing this analysis was introduced in Section 3.3.2.1. Details more specific to Alternative 4 are described below.

HYDRAULICS, FLOW RATES AND VOLUME ESTIMATES DURING CONSTRUCTION

The methods of addressing the impacted pond sediments have been proposed; Alternative 4, sediment excavation with or without complete dewatering of the excavation area (i.e., "wet" or "dry" excavation).

Key assumptions regarding the flow rate estimates are:

- The water levels in the pond are controlled at the sluice gates to the Ogden River. The lowest water level that can be achieved using only the sluice gates is 4266.5 feet amsl. With either alternative, it is assumed that water levels would be lowered to this level before construction begins.

- For the "wet" excavation option of Alternative 4, it is assumed that dewatering would be performed to maintain a water level of 4266.5 feet amsl inside the cofferdam.

- For "dry" excavation option of Alternative 4, it is assumed that dewatering would lower water levels inside the coffer dam to the top of the alpine clay layer (elevation 4262.5 feet amsl). Dewatering would occur in two phases. In the first phase, pumping rates would need to be fast enough to remove the existing water inside the cofferdam as well as water flowing into the pond from natural gradients. The first phase would result in peak flow rates and is assumed to be complete in one week. Once the pond is completely dewatered, phase 2 would consist of continued pumping to maintain a dewatered pond.

- The cofferdam is assumed to prevent pond water from infiltrating back through the cofferdam. Groundwater infiltration into the dewatered area is assumed to be limited to the perimeter of the area that is pond bank.

Based on the dewatering calculations, a dewatering flow rate of 170 gpm would be need to be maintain pond levels at 4266.5 feet amsl for wet excavation. If "excavation in the dry" is employed, flow rates during the first phase of dewatering could reach 230 gpm. Once the pond is dewatered, calculations indicate a flow rate of 200 gpm would be needed to maintain dewatered conditions.

Excavating in the "wet" is potentially a slower operation that excavation in the "dry". Even though the dewatering rate would be lower, calculations indicate that the higher construction time using the excavation in the "wet" option results in treatment of nearly the same volume of water (about 5 to 6 million gallons) as the excavation in the "dry" option.

POND HYDRAULICS AFTER CONSTRUCTION

The pond hydraulics during construction would be similar to Alternative 5 in that a net gradient toward the pond would be created during the dewatering process. However, the pond hydraulics after construction would be different from Alternative 5 and for Alternative 3 because no permanent barrier would be left in place because the coffer dam would be removed and no sheet pile would be installed along the pond bank. The sheet pile would not be required because of the active and aggressive DNAPL recovery activity outside the pond.

TREATMENT PROCESSES

The wastewater treatment process described in Section 3.3.2.1 would be implemented for Alternative 4 also. The objective of the treatment process would be to remove oil (DNAPL), sediments, and dissolved phase to the extent needed to meet treatment standards. Regardless of whether Alternative 3, 4, or 5 is selected, the approach to treatment would be similar.

EXCAVATION AND DISPOSAL OF CONTAMINATED POND BOTTOM MATERIALS

All DNAPL-impacted sediments and gravels identified by visual discolorations within the area confined by the cofferdam and the barrier wall will be removed to a depth 0.5 feet below the top of the Alpine clay. Clean sediments and gravels within the cofferdam but outside the limits of the residual DNAPL would not be excavated. Clean overburden on the shoreline of the pond will be stockpiled for later restoration of the shoreline.

Excavated sediments and gravels that are water-saturated will be placed in a temporary stockpile to gravity drain. Cement (a drying agent) will then be mixed into the pond bottom materials to stabilize pore water. The excavated materials will be drained and the cement will be added in the pond bottom or in the clearing area east of the barrier wall. The stabilized waste material will then be hauled as a petroleum waste in water-tight trucks and/or railcars to an offsite area for disposal. Approximately 2,400 cubic yards of excavated pond bottom materials will be removed for disposal. After mixing with cement, this results in approximately 4,000 tons of material requiring disposal[5].

The DNAPL-impacted pond bottom materials to be excavated from the 21st Street Pond are not deemed to be RCRA-hazardous based on the following comparisons.

- A sample of pure DNAPL oil was collected from well 33-MW1FP on 7-11-00. This sample was analyzed for ignitability, reactivity, and corrosivity characteristics. Results of the analyses show that the oil is non-corrosive and non-reactive. The flashpoint (ignitability parameter) for pure DNAPL oil is 125^0 F, which fails the ignitability test of <140^0 F. However, given the fact that the impacted pond bottom materials are water-saturated and mixed with soils, the excavated material is anticipated to have a flashpoint in excess of 140^0 F. This conclusion will be verified during remedial action design by sampling and analysis of DNAPL-impacted sediment samples for waste profiling purpose, which will include ignitability testing.

- As a class of MGP waste, this material is exempt from TCLP analysis.

[5] The excavated volume of DNAPL-impacted material to be excavated is 1,976 cubic yards, based on a surface area of 18,400 square feet, at an average depth of 2.9 feet. The average density of the excavated material is estimated to be 118 lbs/ft^3, based

BACKFILL THE EXCAVATED POND AREA AND REMOVAL OF THE TEMPORARY COFFERDAM

The shoreline will be restored to its present aerial extent. Clean overburden removed from the shore during the excavation operation will be returned to the shoreline. Residual stringers of DNAPL that are identified and cannot be removed will be covered with 1 foot of clay material. The temporary cofferdam will be removed and the soil material will be spread into the excavated pond area. (Cofferdam material that is impacted by DNAPL during the excavation will be removed, stabilized, and disposed of off-site, so the remaining materials will be suitable for placement as fill in the pond.)

FENCING AND SITE ACCESS

After construction of Alternative 4 is complete, the chain link fence constructed as an interim measure in May 2001 will be removed and the site can again be opened to public access. The monitoring/recovery wells and observation sump will be designed with locking, watertight covers to prevent public access and protect the sump during flooding.

REVEGETATION

Alternative 4 requires the removal of the vegetation along the banks of the pond confined by the cofferdam. This area will be revegetated.

MONITORING AND DNAPL RECOVERY

DNAPL that accumulates in the recovery sump south of the pond will be removed. The sump and well 33-MW6FP will be monitored monthly to detect DNAPL, if any. Because DNAPL accumulation is not expected, no active, permanent DNAPL recovery systems will be installed, but DNAPL may be recovered using a vacuum truck or other recoverable DNAPL pumping system, as needed.

on a gravel density of 136 lbs/ft^3 and sediment density of 100 lbs/ft^3. It was assumed that 5 pounds of cement would be required to stabilize each cubic foot of DNAPL-impacted material.

3.4.2.2 *Intensive DNAPL Recovery*

The DUS/HPO process was selected as a representative aggressive DNAPL recovery technology to determine if this type of approach provided any practical benefit at the site. This assumes that the general evaluation of the steam-enhanced recovery is essentially the same as for other aggressive recovery technologies relative to concept and effectiveness. If this representative approach is chosen, further optimization of the treatment approach would be included later.

The conceptual design for the Northern Area was developed with assistance from personnel at Steamtech Environmental Services.[6] The basic components of the DUS/HPO process are discussed below.

- Given the depth of the DNAPL and site geology, up to 1,000 injection wells would be needed to cover the site (Figure 3-7). It is assumed that injection wells would be spaced at a maximum of 40 foot centers. Steam would be injected at a rate of 50,000 lbs/hour (maximum total), which translates to 5,000 lbs/hr/well.

- The depth to the top of the "heated zone" is assumed to be 13 feet. Over an 11 acre site, this translates to a treatment volume of approximately 225,000 cubic-yards.

- An estimated 117 liquid extraction wells would be capable of producing up to 3 gpm of liquids per well. The total liquid extraction rate is estimated to be 350 gpm.

- Extracted fluids would pass through a heat exchanger and then be separated into DNAPL, water, and vapor. The DNAPL would be collected in a holding tank; the vapor would be treated using a vapor phase granular activated carbon system ("GAC") and discharge to the atmosphere; the water would be treated using a GAC system and discharged to a city sewer under permit.

- Treatment would occur over four phases: a heat up phase (95 days), pressure cycling phase (1,941 days), extraction phase (10 days), and cool-down phase (100 days). The estimated treatment time (not including the time to construct the system) is 6 years.

[6] Steamtech performed the DNAPL treatment at the Visalia Pole Yard.

3.4.3 Cost Estimate

Based on the number of wells discussed in the text (1,117), preliminary cost information indicates that the DUS process alone could cost $49.75 million. As shown in Appendix H, the total cost to implement the complete alternative is $50.43 million.

3.5 Alternative 5 – Pond Sediment Excavation Remedy with DNAPL Recovery and Institutional Control

The focus of this alternative is aggressive and intensive efforts to remove DNAPL from the 21st Street Pond and surrounding areas. The key active technologies that would be employed include excavation and off-site disposal of pond sediments and impacted soil and DNAPL recovery by pumping from DNAPL impacted areas outside the pond.

3.5.1 Concept

3.5.1.1 Pond Sediment Remedy

Alternative 5 addresses the risk posed by DNAPL-impacted pond bottom materials in the 21st Street Pond materials by removing them and disposing them in an off-site disposal facility. Major components of this alternative are briefly described as follows:

- A cofferdam will be installed to hydraulically isolate the DNAPL-impacted pond zone, to enable water level control of this zone and subsequent wet excavation of DNAPL-impacted pond bottom material.

- After the excavation zone has been isolated and water levels controlled, the impacted pond bottom material will be removed and mixed with a stabilizing agent such as cement. The stabilized material will then be transported to a disposal facility.

- The cofferdam will then be removed, and the area where excavation took place will be restored to a physical condition similar to that at the site before construction began.

- A barrier wall will be installed in the former DNAPL flow path, to ensure that future migration of DNAPL into the remediated area does not occur.

DNAPL recovery for Alternative 5 is illustrated in Figure 3-8. It is estimated that the water management period required for Alternative 5 is approximately 6 weeks (4 weeks for excavation and 2 weeks for backfill of the banks). The total construction time for Alternative 5 is estimated to be approximately 5 months.

3.5.1.2 DNAPL Recovery

DNAPL recovery for Alternative 5 would be implemented as it would for Alternative 3 as discussed in Section 3.3.1.2.

At the completion of intensive DNAPL recovery efforts, a network of monitoring wells in the DNAPL zone or just beyond it would be sampled (Figure 3-1). Groundwater samples would be analyzed for the chemicals that compose the DNAPL, VOCs (benzene and ethylbenzene) and SVOCs (PAHs). Data would be analyzed both spatially and over time (that is, concentration vs. time and concentration versus distance) to determine what trends (if any) are apparent.

3.5.1.3 Institutional Controls

Institutional controls include access restrictions and monitoring. Access restrictions include providing a notice in the site property deed restricting groundwater use and placing covenants on off-site properties restricting groundwater use and well installations. Further discussion of these institutional controls was provided by UPRR in Appendix G.

3.5.2 Conceptual Design

3.5.2.1 Pond Sediment Remedy

The conceptual design for excavation and disposal of 21st Street Pond sediment is similar to that described for Alternative 4 as discussed in Section 3.4.2.1 with the following exceptions. The most significant difference between the excavation approach proposed in Alternative 4 and that proposed for Alternative 5 is the installation of a barrier wall along the entire 21st Street Pond shoreline within the excavation area. Because Alternative 4 involves aggressive excavation of DNAPL impacted sediments inside and outside of the pond area, the additional barrier required for Alternate 5 would not be necessary in Alternative 4. This barrier wall required in Alternative

5 is needed to ensure no additional DNAPL impacts to the remediated sediment area, because active DNAPL recovery would be conducted only in areas known DNAPL accumulation.

BARRIER WALL CONSTRUCTION

The approximate location of the sheet pile barrier wall will be the eastern bank of the pond (Figure 3-8). The wall will be deeply embedded into the alpine clay formation and will require large cross-sections capable of resisting the large overturning cantilever forces that will occur during the excavation of impacted pond bottom materials. In general, the wall will need to be embedded into the clay twice the height of soil and water above the alpine formation. If this alternative is carried forward into the final design stage, a wall analysis will be performed to determine the necessary embedded depth. A ditch constructed on the eastern (up-gradient) face of the barrier wall (Figure 3-8) will aid in the interception of groundwater that is flowing toward the impacted area. This ditch will direct intercepted groundwater around the eastern face of the wall to a pond outlet. Furthermore, the barrier wall (top elevation 4,268.5 feet amsl) will minimize the amount of Ogden River water seeping into the portion of the pond that will be excavated. Therefore during excavation, nearly all of the groundwater which normally would travel through the excavation zone will be diverted around the excavation area. Oil booms can be constructed to catch any DNAPL sheens that appear on the ditch water.

Wing walls at both ends of the barrier wall will help direct the flow of groundwater to the weir and reduce the probability that DNAPL will migrate around the barrier and into the pond. The southwest wing wall will be extended to the toe of the 21st Street overpass embankment. The northeast end of the wing wall will be extended east to within 40 feet of the Ogden River. The wing walls will be driven approximately 2 feet into the alpine formation and cut off 1 foot below the ground surface to approximately 4,279.0 amsl.

After the impacted pond bottom materials have been excavated, a portion of the barrier wall will be lowered to elevation 4,267.0 amsl. The newly lowered portion of the wall will serve as a weir and allow groundwater to flow over the barrier wall and into the pond at minimum velocities.

DEWATERING DURING CONSTRUCTION

An analysis was performed of; 1) dewatering rates and the volume of water generated during dewatering operations, 2) pond hydraulic conditions during remedial construction, and 3) the potential water treatment operations needed for remedial activities at the 21st Street Pond in Ogden, UT. The approach for performing this analysis was introduced in Section 3.3.2.1. Details more specific to Alternative 5 are described below.

HYDRAULICS, FLOW RATES AND VOLUME ESTIMATES DURING CONSTRUCTION

The methods of addressing the impacted pond sediments have been proposed; Alternative 5, sediment excavation with or without complete dewatering of the excavation area (i.e., "wet" or "dry" excavation).

Key assumptions regarding the flow rate estimates are:

- The water levels in the pond are controlled at the sluice gates to the Ogden River. The lowest water level that can be achieved using only the sluice gates is 4266.5 feet amsl. With either alternative, it is assumed that water levels would be lowered to this level before construction begins.

- For the "wet" excavation option of Alternative 5, it is assumed that dewatering would be performed to maintain a water level of 4266.5 feet amsl inside the cofferdam.

- For "dry" excavation option of Alternative 5, it is assumed that dewatering would lower water levels inside the coffer dam to the top of the alpine clay layer (elevation 4262.5 feet amsl). Dewatering would occur in two phases. In the first phase, pumping rates would need to be fast enough to remove the existing water inside the cofferdam as well as water flowing into the pond from natural gradients. The first phase would result in peak flow rates and is assumed to be complete in one week. Once the pond is completely dewatered, phase 2 would consist of continued pumping to maintain a dewatered pond.

- The cofferdam is assumed to prevent pond water from infiltrating back through the cofferdam. Groundwater infiltration into the dewatered area is assumed to be limited to the perimeter of the area that is pond bank.

Based on the dewatering calculations, a dewatering flow rate of 170 gpm would be need to be maintain pond levels at 4266.5 feet amsl for wet excavation. If "excavation in the dry" is employed, flow rates during the first phase of dewatering could reach 230 gpm. Once the pond is dewatered, calculations indicate a flow rate of 200 gpm would be needed to maintain dewatered conditions.

Excavating in the "wet" is potentially a slower operation that excavation in the "dry". Even though the dewatering rate would be lower, calculations indicate that the higher construction time using the excavation in the "wet" option results in treatment of nearly the same volume of water (about 5 to 6 million gallons) as the excavation in the "dry" option.

It is important to note that during construction whether the sheet pile barrier upgradient of the pond is installed before or after excavation, dewatering during construction would be at the same rate, but a portion of the dewatering may be accomplished upgradient of the barrier wall if the wall is installed before excavation is complete.

POND HYDRAULICS AFTER CONSTRUCTION

The details of the hydraulic modeling using MODFLOW were presented in Appendix L of the Remedial Investigation Report (Forrester, 2003a, Part 2) and Appendix C of the Focused Feasibility Study for the 21st Street Pond (Forrester, 2001). Alternative 5 in the Final FS (Alternative 2 in the Focused FS) utilizes a barrier wall installed into the alpine clay that extends around the eastern end of the 21st Street Pond.

Modeling results for the barrier wall utilized for Alternative 5 indicate only marginally increased hydraulic gradients at the southern end of the barrier wall. However, these hydraulic conditions should not result in undesired DNAPL migration, based on the following considerations:

- The southern end of the sidewalls is outside the projected extend of the DNAPL zone.
- Hydraulic conditions in the area overlying the DNAPL zone should not cause DNAPL migration toward the southern end of the sidewalls.

- DNAPL recovery operations on the up-gradient side of the wall should further mitigate the potential for DNAPL migration to and accumulation at the southern end of the sidewall.

In summary, the location of the barrier wall along the bank of the 21st Street Pond used for Alternative 5 and the height of the submerged weir will not effect adverse DNAPL migration.

TREATMENT PROCESSES

The wastewater treatment process described in Section 3.3.2.1 would be implemented for Alternative 5 also. The objective of the treatment process would be to remove oil (DNAPL), sediments, and dissolved phase to the extent needed to meet treatment standards. Regardless of whether Alternative 3, 4, or 5 is selected, the approach to treatment would be similar.

BACKFILL THE EXCAVATED POND AREA AND REMOVAL OF THE TEMPORARY COFFERDAM

The downgradient side of the sheet pile will be backfilled to the existing grades along the pond shoreline and the shoreline will be restored to its present aerial extent. Clean overburden removed from the shore during the excavation operation will be returned to the shoreline.

Revegetation

Alternative 5 requires the removal of the vegetation along the banks of the pond confined by the cofferdam. In addition, an approximate 30-foot wide strip of vegetation will be disturbed by the construction of the wing wall that stretches toward the Ogden River.

3.5.2.2 Monitoring and DNAPL Recovery

The conceptual design for DNAPL recovery with Alternative 5 is the same at that described for DNAPL recovery with Alternative 3 as discussed in Section 3.3.2.2.

3.5.3 Cost Estimate

Preliminary cost information indicates that the 21st Street Pond sediment excavation and disposal including a protective DNAPL barrier alone could cost $1.2 million. As shown in Appendix H, the total cost to implement the complete alternative is $2.3 million.

4 DETAILED ANALYSIS OF ALTERNATIVES – NORTHERN AREA OPERABLE UNIT

This section includes a detailed analysis of the alternatives to be considered (Table 4-1). The detailed analysis is a multi-step process of evaluating alternatives to allow comparison of the alternatives and to identify the key trade-offs among them. During the detailed analysis, each alternative is assessed against the evaluation criteria described in Section 4.1. The results of the detailed analysis, shown in Table 4-1 and discussed in Section 4.2, provide relevant information needed to allow selection of the site remedy.

4.1 EVALUATION CRITERIA

For a remedial action to meet the statutory requirements addressed in the National Contingency Plan ("NCP") (U.S. EPA, 1990), it must:

- Be protective of human health and the environment.
- Attain ARARs or provide grounds for invoking a waiver.
- Be cost-effective.
- Use permanent solutions and alternative treatment technologies, or resource recovery technologies, to the maximum extent practicable.
- Satisfy the remedial action objectives or satisfy the preference for treatment that reduces toxicity, mobility, or volume as a principal element.

In addition, other statutory requirements emphasized by the Comprehensive Environmental Response, Compensation, and Liability Act ("CERCLA") include an evaluation of the long-term effectiveness and the following related considerations:

- The persistence, toxicity, and mobility of the hazardous substances and their constituents.
- Short- and long-term potential for adverse health effects from human exposure.
- Long-term maintenance costs.

- The potential threat to human health and the environment associated with excavation, transportation and re-disposal, or containment.

These requirements have been condensed into nine evaluation criteria, which serve as the basis for evaluating the alternatives in the detailed analysis. These nine criteria include: overall protection of human health and the environment; compliance with ARARs; long-term effectiveness and permanence; reduction of toxicity, mobility, or volume; short-term effectiveness; implementability; cost; state acceptance; and community acceptance. The nine criteria are described in the following subsections.

4.1.1 Threshold Criteria

Assessments against two of the evaluation criteria relate directly to statutory findings that must ultimately be made in the final remedial decision. Therefore, these are categorized as threshold criteria because each alternative must meet them. These two criteria are described below.

4.1.1.1 Overall Protection of Human Health and the Environment

The assessment against this criterion describes how the detailed alternative, as a whole, provides adequate protection of human health and the environment and meets the remedial action objectives. This evaluation focuses on how the remedial action objectives are met through treatment, engineering, or institutional controls.

4.1.1.2 Compliance with ARARs

Remedial actions must meet any federal or state standards, requirements, criteria, or limitations that are determined to be legally applicable or relevant and appropriate requirements ("ARARs"). Each of the four alternatives was evaluated based on the three general ARAR categories: chemical-specific ARARs, location-specific ARARs, and action-specific ARARs. Compliance with ARARs is discussed later in this section and a comparison is included in Table 4-1. Table 4-2 provides a more detailed summary of each ARAR and its applicability to the remedial action alternatives considered.

CHEMICAL-SPECIFIC ARARS

Chemical-specific ARARs are standards pertaining to the amount or concentration of a chemical allowed or discharged in the environment. These values are derived from health- or risk-based calculations incorporating the chemical characteristics, the media of concern, and potential exposure pathways. Chemical-specific ARARs for the site include groundwater and surface water criteria.

Three categories of groundwater protection standards are considered by Superfund as potentially applicable or relevant and appropriate requirements: background concentrations, maximum concentration limits ("MCLs"), and alternate concentration limits ("ACLs"). In general, Superfund will find MCLs under the Safe Drinking Water Act the relevant and appropriate requirements for most sites.

Superfund considers the potential adverse effects on groundwater quality and hydraulically-connected surface water and other factors in evaluating the use of ACLs. CERCLA 121(d)(2)(B)(ii) provides a set of three additional conditions limiting the use of ACLs at Superfund sites where MCLs would otherwise be applicable or relevant and appropriate. The statute prohibits use of any process for establishing ACLs for hazardous constituents in groundwater (where there is not a projected entry into surface water) for purposes of an on-site cleanup that assumes a point of human exposure beyond the boundaries of the facility, except where three specific conditions are met:

- There are known and projected points of entry of such groundwater into surface water
- On the basis of measurements or projections, there is or will be no statistically significant increase of such constituents (above surface water criteria) from such groundwater in such surface water at the point of entry (Ogden River or 21st Street Pond) or at any point where there is reason to believe accumulation of constituents may occur downstream
- The remedial action includes enforceable measures (that is, institutional controls) that will preclude human exposure to the contaminated groundwater at any point between the facility boundary and all known and projected points of entry of such groundwater into surface water.

A site-specific ACL analysis is provided in Appendix F.

LOCATION-SPECIFIC ARARS

Location-specific ARARs are used to identify and protect unique or areas, such as historic areas, wetlands, ecosystems, and endangered species, but also serve to prevent potential hazards associated with working in floodplains or geologically unstable regions. Additional regulations regarding zoning ordinances are also location-specific ARARs.

ACTION-SPECIFIC ARARS

Action-specific ARARs are utilized to determine activity or technology based restrictions on remediation proposals. These requirements may be imposed based on the chemical and disposal/treatment method employed. Several regulations were identified that may impose restrictions on the remediation proposals, including standards outlined in the Occupational Safety and Health Act ("OSHA"), the Clean Air Act ("CAA"), the Clean Water Act ("CWA"), the Resource Conservation and Recovery Act ("RCRA"), and the Toxic Substance Control Act ("TSCA") and analogous rules and regulations for the state of Utah. Additional action-specific ARARs include requirements for construction permits and adhering to building codes.

4.1.2 Primary Balancing Criteria

The following five criteria described below are grouped together because they represent the primary criteria upon which the analysis is based.

4.1.2.1 Long-Term Effectiveness and Permanence

The evaluation of detailed alternatives under this criterion addresses the results of a remedial action in terms of the risk remaining at the site after remedial action has been implemented. This assessment includes an analysis of the magnitude of residual risk and the adequacy and reliability of engineering or institutional controls. The magnitude of residual risk analysis takes into account the following:

- Residual risk, expressed in cancer risk levels, volumes, or concentrations remaining from untreated waste or treatment residuals at the conclusion of remedial activities.

- The volume, toxicity, and mobility of residuals remaining after remedial activities.

The adequacy and reliability of engineering or institutional controls is evaluated in terms of the long-term reliability of controls used to manage treatment residuals or untreated waste remaining at the site, and considers the following:

- The likelihood that the technology would meet required process efficiencies or performance specifications;
- The type and degree of long-term management and monitoring;
- Operation and maintenance ("O&M") functions required to maintain process efficiencies or performance specifications;
- Difficulties of long-term maintenance, including the potential need for replacement of technical components, the risks should the components need replacement, and the degree of confidence that controls can adequately handle potential problems.

4.1.2.2 Reduction of Toxicity, Mobility or Volume

This criterion is based on a preference for treatment technologies that irreversibly reduce toxicity, mobility, or volume of the compounds-of-interest. The primary concern is whether the detailed alternative would satisfy this preference for treatment as a principal element (treatment is defined in the U.S. EPA guidance as the destruction of toxic COCs, reduction of the total mass of toxic COCs, irreversible reduction in contaminant mobility, or reduction of total volume of contaminated media).

The focus of this criterion is whether the proposed detailed alternative reduces the principal threats through treatment. Some considerations under this detailed alternative include the following:

- The treatment process and remedy; whether the treatment process addresses the principal threats, and whether there are any special process requirements or limitations.
- The mass and volume of material destroyed or treated.

- The extent to which the total mass, mobility, and volume of toxic COCs are reduced, and whether or not the reduction is irreversible.
- The type, quantity, and characteristics of treatment residuals, and the risks posed by the residuals.
- The statutory preference for treatment as a principal element.

4.1.2.3 Short-Term Effectiveness

This criterion addresses the effects of the detailed alternative during the construction and implementation phases until remedial action objectives are met, and considers the following:

- The risks, which could not be readily controlled during remedial actions, to site remediation workers and the methods used to mitigate the risks.
- The risks to the community during the remedial action, and how the risks would be mitigated.
- Environmental impacts which can be expected during construction and implementation, the mitigation measures and their reliability, and the impacts which can not be avoided or controlled.
- The length of time until remedial objectives are met.

4.1.2.4 Implementability

This criterion addresses the technical and administrative feasibility of implementing a detailed alternative and the availability of various services and materials required during its implementation. Assessment of this criterion relies heavily on previous evaluations of technologies described in Section 3. Specific considerations include the following:

- The ability to construct and operate the detailed alternative, the difficulties and uncertainties which may be encountered during construction, and the likelihood of technical problems which may lead to schedule delays.

- The ease of undertaking additional remedial action, and what those additional actions may be.
- The coordination required between agencies over the long term, and the ability to obtain permits for the remedial activities.
- The availability of capacity at treatment, storage, and/or disposal services, and the measures required to ensure that capacity is available.
- The availability of necessary equipment and specialists, and whether a lack of equipment and specialists prevents implementation.
- The degree to which technologies are available and sufficiently demonstrated for the specific full-scale application.

4.1.2.5 Cost

The cost analysis includes estimates of capital costs (both direct and indirect) and annual O&M costs associated with each component of a detailed alternative. The target level of accuracy is +50 percent to -30 percent. Total cost was estimated based on a present worth analysis using a net interest rate of 7 percent.

The cost may play a significant role in comparing detailed alternatives which are similar in long-term effectiveness, or in which the treatment methods provide a similar performance. The detailed alternatives with costs that are high when compared to the overall effectiveness of the detailed alternative will not be selected as the final remedy. Similarly, non-treatment alternatives that have low initial capital costs may be more costly overall than a treatment alternative when long-term O&M costs are considered. An improved performance or greater long-term risk reduction may justify higher costs. The preferred detailed alternative is generally the one that satisfies the criteria at the most reasonable cost.

4.1.3 Modifying Criteria

The final two criteria are not evaluated directly in this FS, but will be evaluated following comment on the FS report and the proposed plan and will be addressed once a final remedial action decision is being made.

4.1.3.1 State Acceptance

This criterion evaluates the technical and administrative issues and concerns the State, or support agency, may have regarding each of the detailed alternatives. This criterion is not addressed at this time.

4.1.3.2 Community Acceptance

This criterion evaluates the issues and concerns the public may have regarding each of the detailed alternatives. As with the State acceptance, this criterion is not addressed at this time.

4.2 COMPARATIVE ANALYSIS

A detailed comparative analysis is shown in Table 4-1. The No Action alternative (Alternative 1) is not discussed because it does not meet any RAOs. The remaining alternatives are compared and contrasted below.

4.2.1 Overall Protection of Human Health and the Environment

- Alternatives 3, 4, and 5 are the alternatives that best address the RAOs.

- The only RAO not achieved by Alternatives 3 and 5 is restoration of groundwater to beneficial uses, which none of the alternatives can reliably accomplish. The Forrester Group is not aware of any site with a large DNAPL zone at which restoration to drinking water quality criteria throughout the impacted zone has been achieved and documented. Given the paucity of documentation on the actual restoration of groundwater zones containing DNAPL (despite many remediation projects have this objective), there is widespread concern that groundwater restoration (that is, achievement of MCLs) in an extensive DNAPL zone is technically impracticable. Given that there is significant doubt as to the ability of even Alternative 4 to achieve complete groundwater restoration remains (achievement of drinking water quality throughout the DNAPL zone), and in light of both the long-term and short-term effectiveness considerations summarized in Table 4-1, there is uncertainty as to whether "intensive DNAPL zone treatment" (Alternative 4) offers significant and tangible benefits in terms of overall protection of human health and the environment relative to DNAPL recovery with MNA and controls (Alternatives 3 and 5).

- Only Alternatives 3, 4, and 5 protect human and ecological receptors from exposure to DNAPL contaminated sediments in the pond. Once these sediments are either capped (Alternative 3) or excavated (Alternatives 4 and 5), this RAO is achieved.

- Alternatives 2 through 5 prevent unacceptable risk to current and future humans presented by direct contact, inhalation, and ingestion of contaminated groundwater. (No current exposure exits; as discussed in Section 1.2.5.1, protection from future exposure is achieved quickly with ICs). Alternatives 3, 4, and 5 remove DNAPL to reduce the potential for further spread of the DNAPL.

4.2.2 Compliance with ARARs

- Alternatives 2 through 5 would meet action specific and location specific ARARs.

- As discussed in Appendix F, site conditions are appropriate for applying ACLs as the chemical-specific ARARs for groundwater at this site. With Alternatives 2 through 5, compliance with ACLs could be quickly demonstrated.

4.2.3 Long-Term Effectiveness and Permanence

- **21st Street Pond.** In Alternative 3, residual risk from Pond sediments is reduced by capping them in place. In Alternatives 4 and 5, residual risk is reduced by excavating and disposing them. Either method is capable of reducing pond sediment risk to acceptable levels.

- **Areas outside the 21st Street Pond.** With Alternative 2 through 5, ICs would be enforceable and monitoring would be used to demonstrate effectiveness of controls. For this criterion, long-term effectiveness and permanence would be provided by the combination of contaminant mass removal (the degree of which is variable among the alternatives) and ICs (which are common to each of the alternatives).

4.2.4 Reduction in Toxicity, Mobility, or Volume

- Alternatives 3, 4 and 5 reduce mobility and volume of DNAPL. A larger volume of DNAPL could potentially be removed with Alternative 4. Appreciable reduction in mobility and volume of DNAPL would not occur in Alternative 2 (over and above the DNAPL removal already accomplished).

4.2.5 Short-Term Effectiveness

- Alternatives 3 and 5 are also the only alternatives that achieve all of the RAOs in relatively short time period, except for restoration of groundwater to beneficial uses.

- Alternatives 3 and 5 are protective of remediation workers, the community, and the environment. Implementation of DUS/HPO in Alternative 4 could potentially have adverse effects on nearby surface water.

4.2.6 Implementability

- There are no technical barriers to implementability of Alternatives 2, 3 or 5. Preventing steam from migrating to and impacting the 21st Street Pond and Ogden River presents a technical challenge to Alternative 4. Dynamic underground stripping beneath active rail lines and highways would also not be practical.

- Equipment and materials to implement Alternatives 2, 3 and 5 are readily available. On the other hand, DUS/HPO is a patented technology that is only offered by a limited number of vendors. Supply of services and parts to implement Alternative 4 could potentially be problematic.

4.2.7 Cost

- Capital costs for Alternative 3 are estimated to be $500,000 (see pages 3 and 4 of Appendix H for detailed derivation of capital cost portion of the cost estimate for the alternative); operation and maintenance costs are estimated to be $1,107,000.

- The capital cost to implement Alternative 5 would cost would be more than 2-times the capital cost to implement Alternative 3.

- Alternative 4 could cost approximately 30-times more than Alternative 3.

5 CONCLUSIONS AND RECOMMENDATIONS – NORTHERN AREA OPERABLE UNIT

Based on the comparative analysis performed in Section 4.2 (Table 4-1), key remedy selection considerations are as follows:

- The UPRR Project team is not aware of any site with a large DNAPL zone at which restoration to drinking water quality criteria throughout the impacted zone has been achieved and documented. Therefore, groundwater restoration (that is, achievement of MCLs) is considered technically impracticable.

- Alternative 3 reliably achieves all of the remaining RAOs in a relatively short time period (that is, a few years).

- Alternative 3 addresses the DNAPL impacted pond sediments by capping them in place. Once these sediments are capped, human and ecological receptors will be protected from direct exposure to the sediments. Capping the DNAPL sediments in place is consistent with the remedial action component for the DNAPL zone (waterflood DNAPL recovery), in that both alternatives will rely on institutional and/or engineering controls to manage the potential risk posed by residual DNAPL-impacted soils and sediments.

- Alternatives 4 and 5 include excavation and off-site disposal of DNAPL-impacted sediment and soil from the 21st Street Pond. Although the intent of the excavation is to remove all of the impacted sediment and soil, it is possible that a fraction of the material may not be removed due to limitations in locating the impacted material and in effectively removing the sludge and soil from the saturated pond bottom. While confirmation sampling may have limitations with regards to verifying that all DNAPL-impacted material has been removed, it is still the most effective method to verify that standards or criteria have been achieved.

- Relative to Alternative 3, Alternatives 4 and 5 incorporate a significantly higher level of effort and cost in reducing contaminant concentrations. However, even after this more intensive and costly remedial action effort, long-term site management requirements (for example, the need for institutional controls to manage residual impacts) would remain essentially the same as for Alternative 3.

- Alternative 4 poses a significant challenge with respect to protection of human health and the environment during remedial action. Because the DUS process relies on making the DNAPL more mobile, there is an accompanying potential for unintended contaminant redistribution. Preventing the mobilized DNAPL from impacting water quality in the 21st Street Pond would be of particular concern.

Based on alternative comparison presented in Section 4, including the above considerations, Alternative 3 is the preferred alternative. Alternative 3 meets the threshold criteria and clearly provides greater value than the other alternatives. In summary, the recommended alternative consists of the following:

- DNAPL impacted 21st Street Pond sediments will be contained and capped in place (Figures 3-2 and 3-3). A cofferdam will be constructed in the pond's southeast corner to segregate the DNAPL impacted sediments from the remainder of the pond, and then the sediments will be backfilled to eliminate the potential exposure pathway. The estimated construction time for capping the sediments in place is 16 weeks.

- DNAPL recovery will be performed to deplete continuous phase DNAPL. A maximum of four pools of potentially recoverable DNAPL have been identified and each will be depleted to the extent practicable. DNAPL recovery will be performed by applying the pumping recovery technologies used during the 2002 pilot DNAPL recovery project. The estimated time to complete DNAPL recovery of these areas is 3 years.

- Institutional controls will be applied to ensure that direct contact, inhalation, and ingestion of impacted groundwater will continue to be an incomplete exposure pathway. Institutional controls to could be applied in short time period. Monitoring will continue to be performed to ensure that surface water and other groundwater in the vicinity of the site are protected.

6 DEVELOPMENT OF ALTERNATIVES – RAIL YARD GROUNDWATER OPERABLE UNIT

An initial selection of technologies which appear to be the most likely candidates for implementation at the Ogden Rail yard site was completed (Appendix A). The initial screening that was performed and the RAOs agreed to with the agencies were used to develop the list of alternatives discussed in this section. Remedial Action Alternatives to be evaluated for the Rail Yard Groundwater OU ("OU-04") are as follows:

1. No further action.

2. MNA. Evaluation of this alternative will incorporate the results of the additional groundwater monitoring and natural attenuation characterization work discussed in Section 1.2.4.1.

3. Focused source removal with MNA. This alternative will include actions to address the wastewater sewer lines and machine shop associated with the former Southern Pacific Railroad ("SP") facilities, which appear to be a potential source of ongoing CVOC loading to the North CVOC Plume.

4. Aggressive source area remediation with MNA. This alternative will include actions to more aggressively treat potential sources of ongoing CVOC loading to the North CVOC Plume. This alternative considers air sparging in the zones of highest CVOC concentration.

5. Perimeter groundwater treatment. This alternative will include actions to actively treat groundwater along the site perimeter, to mitigate the potential for offsite migration of CVOC-impacted groundwater. This alternative is comprised of a line of air sparging wells that will create a treatment zone through which impacted groundwater must pass before offsite migration.

6. Aggressive Source Area Remediation and active groundwater remediation with the objective of restoration of groundwater beneficial use as expeditiously as possible. This alternative considers air sparging over the entire extent of VC impacts.

6.1 ALTERNATIVE 1 – NO FURTHER ACTION

This alternative serves as the baseline for comparison of other alternatives. With this alternative, no monitoring, control, or treatment of impacted media is performed.

6.2 ALTERNATIVE 2 – MNA

This alternative relies on the natural attenuation processes at the site to meet the remedial objectives for the Ogden Rail yard groundwater.

6.2.1 Concept

In their technical directive (OSWER 9200.4-17P) on the use of MNA, the USEPA (1999) defines MNA as follows:

"The reliance on natural attenuation processes (within the context of a carefully controlled and monitored site clean-up approach) to achieve site-specific remediation objectives within a time frame that is reasonable compared to that offered by other more active methods. The 'natural attenuation processes' that are at work in such a remediation approach include a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. These in situ processes include biodegradation; dispersion; dilution; sorption; volatilization; radioactive decay; and chemical or biological stabilization, transformation, or destruction of contaminants."

The USEPA also states that "Sites where contaminant plumes are no longer increasing in extent, or are shrinking, would be the most appropriate candidates for MNA remedies".

Given these policy statements, this alternative will be developed around the following main concepts:

- MNA is an appropriate remediation method where its use will be protective and it will be capable of achieving site-specific RAOs within a timeframe that is reasonable compared to other alternatives.[7]

- Concentration vs. time and concentration vs. distance data should indicate that the plumes are stable or shrinking.

- Adequate performance and contingency remedies, if needed, should be utilized until remediation objectives have been achieved.

6.2.1.1 *Natural Attenuation Processes at the Site*

Appendix E presents a revised analysis of natural attenuation processes at the site. Based on this analysis, strong evidence for complete reductive dechlorination of chlorinated solvents (that is, VC to ethene) exists for the north plume. Given that the geochemical environments in the north and south plumes are likely very similar (that is, diesel LNAPL producing reducing conditions favorable for reductive dechlorination), complete reductive dechlorination of VC in the south plume is also likely. Other processes capable of attenuating the VC plumes include dilution due to rainwater infiltration, dilution due to Weber River water that is lost to site groundwater in the proximity of the river bank, and plume dispersion resulting from groundwater mixing.

6.2.2 Conceptual Design

The *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater* (USEPA, 1998) was applied to this site to evaluate this alternative. Steps 1-7 of the protocol are discussed in Appendix E. Step 8 (preparation of a long-term monitoring and verification plan for the site) is discussed below.

Continued sampling would continue until remedial action objectives are achieved. The purpose of this sampling would be used to identify any new releases that could impact efficacy of natural attenuation, detect changes in environmental conditions that could reduce the efficacy of natural attenuation process, and to demonstrate that:

- Natural attenuation is occurring according to expectations;

[7] Section 7.1 compares the reasonableness in the time required for MNA to achieve the site RAOs to that of other alternatives.

- The plume is not expanding or significantly increasing in concentration;

- Plume concentrations are below performance criteria at the downgradient point of compliance (demonstrate and verify efficacy of ICs to protect potential receptors); and

- Remediation objectives have been attained.

In the next five years (leading up to the first EPA five-year review), performance monitoring and reporting will be conducted based on the following conceptual design. It is anticipated that the performance verification monitoring plan may change over time based on sampling data.[8]

- On a semi-annual basis (spring and fall), samples will be collected from 20 north and south plume monitoring wells and analyzed for VOCs (Table 6-1 and Figures 6-1 and 6-2). Water level gauging would be performed at 50 wells to determine direction and gradient of groundwater flow. The list of wells and sampling procedures is equivalent to that approved in the Additional Sampling Work Plan (April 21, 2003) to Assess MNA.

- On a semi-annual basis (spring and fall), a sample would be taken from the 21st Street Pond along the discharge (south) side of the pond to confirm that VC levels in the pond do not present a risk.

- Every other year, samples would be collected during spring and fall from 9 north plume monitoring wells and analyzed for geochemical parameters (Table 6-1).

- Data would be analyzed for concentration vs. time and concentration vs. distance on an annual basis. The data and the analysis would be presented to USEPA in an annual report.

- Once every 5 years, a summary report of data collected over the previous 5 years would be submitted to USEPA. This report would also include an evaluation of an institutional control plan for the site.

[8] For example, if VC is not detected at a particular well for several consecutive years, then additional sampling at that location may not be warranted. Also, reduced sample reporting frequency may also be appropriate.

Contingency remedies would be based on compliance of groundwater concentrations at 35-MW1 with the VC ACL (Appendix F). As demonstrated in Appendix F, VC levels could reach 9.6 mg/L at the plume edge and applicable surface water quality standards would not be exceeded. Given that the highest VC concentration ever measured anywhere in the north plume is 3.1 mg/L, it is unlikely that that plume would ever be a risk to the pond. If for unforeseen reasons plume concentrations were to increase to the ACL, then:

- An investigation would be performed to determine whether a new release has occurred. However, given the absence of a new release, plume levels should not increase.
- If the release is due to rail yard activities, UPRR would provide a corrective action plan to the agencies within 60 days of the exceedence.

6.2.3 Cost Estimate

As shown in Appendix H, the total cost to implement this alternative is $550,000.

6.3 ALTERNATIVE 3 – FOCUSED SOURCE REMOVAL WITH MNA

This alternative includes focused source removal combined with the continued monitored natural attenuation from Alternative 2. Focused source removal relies on removal of industrial wastewater sewer line contents (sludge and sediment) that is considered a possible source of CVOC impacts to groundwater in the northern groundwater CVOC plume. Additional removal activities include excavation and removal of sections of the main sewer trunk line composed of vitrified clay, along with impacted soil and bedding material.

6.3.1 Concept

Sampling of industrial wastewater sewer line contents during the remedial investigation indicates the presence of relatively high concentrations of CVOCs (19,000 ug/L 1,2-DCE, 5,400 ug/L 1,1-DCA, and 1,900 ug/L 1,1,1-TCA). The magnitude of these concentrations suggest that residual sludge in the sewer line may be acting as a source of CVOCs to runoff flowing into unplugged storm water inlet drains along the western line. The industrial sewer pipeline network is shown in Figure 6-3a. The main sewer trunk line is constructed of 10-inch diameter vitrified clay pipe composed of 4-foot sectional lengths and, as a result of leakage, may be considered a potential on-going source of CVOCs to the groundwater. Inflow into the sewer line is occurring from storm water running off into unplugged or existing drains from the old machine shop, roundhouse, and the former transfer rail yard area ("38-WW7") connected to the sewer line. Due to the possibility that the sewer is acting as a potential source of contamination to the groundwater in the northern CVOC plume area, the main sewer trunk line will be excavated and removed while other sections will be plugged and sealed as part of the source reduction/removal alternative. The maximum sewer line depth is about 6.5 feet below ground surface which is above the typical depth to groundwater of 10 feet.

Based on experience at other railroad sites, drains, pits or sumps within the footprint of the old machine shop may represent a second source of CVOCs to soil and groundwater. The existence and exact location of drains, pits or sumps in the old machine shop was evaluated based on historical records and historic facility drawings and maps. A focused investigation was conducted in March 2004 to evaluate the potential existence of a subsurface source of chlorinated volatile organic compounds beneath these targeted potential release points. The results of this investigation are discussed in Appendix C. Based on the results as described, no additional source removal is considered for this area at this time.

EPA states in its technical directive on MNA that it *"expects that source control measures will be evaluated for all contaminated sites and that source control measures will be taken at most sites where practicable."* Removal of the sewer pipe sludge in Alternatives 3 is a source removal option that removes or immobilizes to the extent practicable a potentially significant source. The occurrence of and long-term potential for MNA in the northern area plume, where the sludge-containing sewer lines and old machine shop are located is evaluated in Appendix E. This analysis indicated that MNA is occurring and that the northern groundwater plume may have reached steady state. Furthermore, that analysis of source control measures described in Appendix B suggests that removal of source material such as the sewer line sludge containing CVOCs may achieve long-term benefits, particularly in situations where the location and mass of material impacted with relatively high concentrations of CVOCs can be accurately defined.

6.3.2 Sewer Pipe Cleaning Process

A video survey of the line was attempted in December 2003 to determine the present condition of the line and a rough estimate of the volume of sludge present. Because of the narrow diameters of the various lines, presence of sludge, and presence of water, only 179 feet of the originally planned 1,613 feet could be inspected. The limited survey did provide information on the type of sewer pipe and degree of buildup in the vicinities of the manholes used to insert the camera. The type of pipe is shown on Figure 6-3a. In summary:

- The NNW trending trunk line extending NNW from manhole 38-WW4 to 34-WW1 consists of a 2,270 foot length of 4-foot section vitrified clay pipe (VCP), 10-inches in diameter. An additional 180-foot run extends eastward from 38-WW4 for a total VCP length of 2,450 feet. Observed buildup of sediment and sludge ranges from three to four inches.[9]

- The line running west and north of 38-WW6 consists of polyvinyl chloride (PVC) pipe 6-inches in diameter. For the purposes of estimating costs, all tributary lines upstream of the 38-WW6 location are assumed to be of the same material. The total estimated length of plastic 6-inch pipe is 1,290 feet. Observed buildup of sediment and sludge ranges from 1 to 2 inches.

- The line running west of 38-WW8 to the trunk line and south from 38-WW8 consists of 10-inch diameter cast iron or steel pipe (13-foot sections). For the purposes of estimating costs, all tributary lines upstream of the 38-WW8 location are assumed to be of the same material. The total estimated length of 10-inch cast iron or steel pipe is 1,020 feet.

Figure 6-3b provides a map of industrial sewer line locations to be addressed. The sewer line remedy will consist of two portions: (1) sludge cleaning and in-place abandonment of the cast iron/steel and PVC tributary lines and (2) sludge cleaning and removal of the 2,450 foot length of trunk line composed of 10-inch diameter VCP. If it is determined during final design that the sludge in the VCP line can be cost-effectively excavated with the pipe, then the cleaning step will be skipped.

The depth to the bottom invert of the 10-inch VCP sewer line is approximately 6.5 feet below ground surface. The VCP line consists of 4-foot sections of pipe. The trend of this line is consistent with the elongated trend of the northern CVOC plume, which indicates it may have

[9] At the 34-WW1 manhole, the line heads due west under the tracks to the former wastewater treatment plant. Because of the overlying rail tracks, this E-W section of sewer line will be cleaned and abandoned in place.

leaked over time. Liquid in the VCP line will be drained to the concrete lagoon in AOI-34 and then the 2,450 foot length of trunk line composed of 10-inch diameter VCP will be excavated and removed. The ends (at 34-WW1 and 180 feet east of 38-WW4) and junctions of plastic and iron tributary lines remaining in place would be sealed with grout to the extent possible. After removal of sections of VCP sewer line, contaminated soil (identified as being visually contaminated or exceeding a predetermined level as measured by a photo ionization detector) will be removed down to the water table. Confirmation samples will be collected from the bottom of the excavation at the rate of 1 sample per 200 feet of line.

It is assumed that the tributary sewer lines composed of plastic and iron are of good integrity and sludge can be flushed and cleaned. As part of this alternative, the following remedial procedures will be implemented for the tributary lines:

- Sludge Removal: Residual sludge in the 6-inch plastic and 10-inch iron sewers will be removed from the lines at manhole locations and/or additional locations that will be excavated to facilitate the removal. Sludge will be removed from the lines using a combination sewer cleaning system, which utilizes a vacuum pressure on one end and a high pressure water line on the other. The estimated volume of sludge in these lines is 10.5 CY. (The estimated maximum volume based on all runs (Figure 6-3b) of the 10 diameter cast iron sewer and 6-inch diameter plastic sewer being full is 30 cy.)

- Sludge analysis: A toxicity characteristics leaching procedure ("TCLP") analysis will be performed on sludge samples collected from the waste sludge removed from sewer lines. One sample for every 5 cubic yards of material will be collected and considered representative of the total volume of waste material.

- Sludge disposal: Sludge waste will be disposed of at an appropriate landfill depending on the results of the TCLP analysis. Hazardous materials will be disposed of at Clean Harbor's Grassy Mountain facility. Non hazardous material will be transported to the nearest Subtitle D or C landfill. For the purpose of developing feasibility level cost estimates, it is assumed that all sludge material in the lines is hazardous.

- Sealing and abandonment: Subsequent to cleaning, another video survey will be conducted to assure that the lines are clean. Once waste sludge has been removed, the end of the lines will be plugged with bentonite chips and sealed with cement at manhole junctions and/or other locations to prevent future infiltration of surface water.

6.3.3 Cost Estimate

As shown in Appendix H, the total cost to implement this alternative is $950,000 (sewer remediation and MNA). This estimate will slightly vary depending on the relative proportion of hazardous and non-hazardous sludge removed. Also, it is assumes that all excavated soil is non-hazardous. Soil disposal as a hazardous material would substantially add to the project cost.

It is assumed that the bottom of the pipe was, on average, 4 feet below ground surface and highly impacted soil up to 2 feet below the sewer line would be excavated. The total excavated soil volume would be 2,178 bulk cubic yards of which 1,452 bulk cubic yards would be transported to an off-site landfill for disposal as a non-hazardous industrial waste. Clean overburden (1,452 bulk cubic yards) would be used as trench backfill. The total estimated cost to complete the sewer line excavation and sludge removal would be $400,000.

6.4 ALTERNATIVE 4 – AGGRESSIVE SOURCE AREA REMEDIATION WITH MNA

This alternative adds a more aggressive source area remedial approach (air sparging) to Alternative 3. By adding a more aggressive source remedial approach it is possible that overall remediation times might be reduced, compared to monitored natural attenuation alone.

6.4.1 Concept

In situ air sparging ("IAS") involves injection of pressurized air into the groundwater through sparging wells. Air injected below the water table volatilizes contaminants that are dissolved in groundwater, exist as a separate phase, and/or sorbed onto saturated soil particles. In addition to the air stripping process, air sparging also promotes biodegradation by increasing oxygen concentrations in the subsurface, stimulating aerobic biodegradation in the saturated and unsaturated zones.

Vinyl chloride, the primary constituent of concern in groundwater, is a volatile compound that is readily biodegradable under the aerobic conditions produced by IAS. IAS would also strip the volatile parent compounds (PCE, TCE, and 1,1,1-TCA) from the groundwater into the vadose zone. The more heavily chlorinated parent compounds are generally considered to be recalcitrant in aerobic conditions. However, co-metabolic biodegradation processes may degrade these chemicals as well.

Diesel LNAPL was measured in some areas where high CVOC concentrations were also detected. Petroleum hydrocarbons, including components of diesel LNAPL, are biodegradable under aerobic conditions. However, oxygen concentrations in an area of hydrocarbon contamination are often low, resulting in a low rate of contaminant biodegradation. IAS supplies the needed oxygen to maintain the aerobic conditions needed to promote hydrocarbon biodegradation. Limited stripping and biodegradation of the LNAPL would contribute to LNAPL removal.

Subsurface soils must be amenable to transporting injected air from the well throughout the subsurface, and soils which have a higher permeability are better able to transport air through the saturated zone. Soil types, such as the alluvial gravels found at the site, are suited to IAS. Therefore, air sparging the source zones could be an effective way of treating the CVOCs and hydrocarbons present at the site.

This alternative consists of placing sparging wells into the areas where the highest concentrations of CVOCs have been measured. Although the source of the vinyl chloride has not been found, it is likely near the areas where groundwater concentrations are highest and where parent chemicals have been detected. As IAS depletes the source area mass, VOC groundwater concentrations will decrease. In theory, continued treatment would deplete the source and eventually reduce groundwater to concentrations below site screening levels.

6.4.1.1 Biodegradation of Chlorinated Compounds in the Saturated Zone

Vinyl chloride is readily biodegraded under aerobic conditions. Under natural conditions, the rate of aerobic degradation is limited by the lack of dissolved oxygen and the low rate of oxygen transfer to the saturated zone. Injection of air into the saturated zone significantly enhances oxygen transfer to groundwater and the rate of aerobic biodegradation. On other IAS projects, increases of dissolved oxygen concentrations from less than 0.5 mg/L to more than 4 mg/L have been observed.

There is adequate evidence to indicate that anaerobic biodegradation of chlorinated solvents is occurring. IAS would quickly change the geochemical conditions from anaerobic to aerobic conditions, and reductive dechlorination of the more heavily chlorinated compounds to 1,1-DCA, 1,2-DCE, and vinyl chloride would end. This could lead to increased concentrations of PCE, TCE, 1,1,1-TCA, and 1,1-DCE in the short term if other processes, such as volatilization or co-metabolic biodegradation, are not capable of removing these compounds at a rate faster than the anaerobic processes.[10]

6.4.1.2 Biodegradation of Vinyl Chloride in the Vadose Zone

The COCs present in the subsurface will partition into the injected air at some rate determined primarily by the chemical's Henry's constant, the rate of air injection, and subsurface geology. Given that the COCs are volatile, partitioning into the injected air could be substantial. The diesel LNAPL at the site has likely driven oxygen concentrations in the vadose zone to low levels, which impairs aerobic biodegradation of vinyl chloride. (Typical oxygen concentrations in an area of residual hydrocarbon contamination are lower than 5 percent, compared to atmospheric concentrations of 21 percent). IAS supplies the needed oxygen to the vadose zone and promotes vinyl chloride degradation in the vadose zone. In tests at other sites similar to this one, typical IAS air injection rates are sufficient to maintain aerobic conditions in the vadose zone overlying the IAS target area.

6.4.1.3 Displacement of CVOCs

IAS induced volatilization will likely be the major process by which the dissolved CVOCs are removed. CVOCs transported into the vadose zone may continue to migrate vertically to the surface or may travel horizontally along a preferential pathway, such as a conduit. CVOCs that are released to the land surface would be diluted in the atmosphere and degraded by photo oxidization. However, CVOC vapor that is transported into the vadose zone near buildings or conduits could place building occupants at an elevated risk. To prevent exposure to CVOC vapors, a combination of IAS and soil vapor extraction ("SVE") would be performed.

[10] As shown in Figure 5-5 of the RI Report, PCE and TCE are transformed via anaerobic biodegradation to 1,2-DCE and vinyl chloride. Through hydrolysis, 1,1,1-TCA is transformed to 1,1-DCE, which can then be reductively dechlorinated to vinyl chloride.

6.4.2 Conceptual Design

Figures 6-4 and 6-5 show the general areas where source zone sparging would occur in the north and south plumes respectively. Sparging would occur in three areas.

- In the north plume, in a 9 acre area east of the railroad tracks between 22a-MW1 and 38-MW12.
- In the north plume, in a 3 acre area between the railroad tracks and the former lagoons in AOI-34.
- In the south plume, in a 6.5 acre area northeast of 21-MW2.

The conceptual design of the IAS system considered the following key components

- Well design and saturated thickness.
- Well spacing.
- Above-ground process components.

For the purpose of the FS, a modular approach was assumed. Please note that this conceptual design was prepared for the purposes of developing "order of magnitude" cost estimates, appropriate for comparing the relative costs of alternatives. In the event that this alternative would be selected for implementation, the design would need to be refined and revised as appropriate.

6.4.2.1 Northern Plume Source Sparging

WELL DESIGN AND SATURATED THICKNESS

INJECTION

The depth of the air injection well screen is a critical design parameter in air sparging. The selection of the screened interval is based on several considerations.

- Ideally, the top of the injection well screen should be placed at least as deep as the vertical extent of contaminated groundwater.

- The radius of influence of a sparging well is a partial function of the saturated thickness above the well screen. Up to a point, greater saturated thickness above the well screen tends to result in a greater radius of influence.

- The thickness of the water column that will have to be displaced during air sparging (to create air-filled flow paths) is a primary factor in blower sizing.

The screened interval was selected based on a review of site stratigraphy, contaminant distribution, and hydrogeology. The water table is encountered 5-12 feet below grade, in an area composed of alluvial channel deposits that consist of sandy gravel. Underlying the gravel unit is thick clay believed to represent the upper part of the Alpine Clay Formation. Based on the data for key wells in the treatment areas, the depth to clay in the two north plume treatment areas is 14-25 feet below grade. Borings taken across a cross-section in AOI-22a indicated that the depth to clay in this area is approximately 20 feet below grade.

A shallow/deep well pair is present in both the eastern and western treatment areas. Groundwater from these wells is impacted, indicating that chlorinated solvents are present throughout the saturated zone. Therefore, to maximize treatment effectiveness, sparging wells should be installed to the clay/gravel interface. Given the estimated range of depths to clay at wells located in northern plume treatment areas and the borings in AOI-22a, the FS cost estimate assumes that sparging wells will be installed an average of 20 feet below grade.

The thickness of the saturated zone above the injection point was assessed through review of water level monitoring data for wells in the treatment areas. Over the site, the average saturated thickness fluctuated from 7-15 feet. Groundwater levels at specific wells fluctuated as much as 3 feet from the average thickness. A conceptual cross-section for this design is shown in Figure 6-6.

EXTRACTION

Given the shallow water table of the north and south plumes, horizontal wells would provide better vapor recovery than vertical wells. It is assumed that SVE extraction wells would be installed to an average depth of 4 feet bgs. Gravel would then be backfilled over the horizontal wells, and a geomembrane would cover the backfill.

WELL SPACING

INJECTION

The appropriate spacing for IAS wells is best determined through pilot testing. For the purposes of the FS, it is necessary to develop a reasonable estimate of potential well spacing to generate a useable cost estimate for cost comparison with other feasibility study alternatives.

The spacing of the sparging wells is mainly dependent upon the "radius of influence" (the zone in which there is a sufficient frequency of air-filled flow paths) around each sparging well. The radius of influence is best determined through pilot testing. The zone of influence can simplistically be viewed as being a "cone" with dimensions governed by the depth of injection and the angle at which air will move away from the well as it rises through groundwater. The angle of distribution typically ranges between 15 degrees for coarse gravels and 60 degrees for ~~silty~~ sands (Nyer and Suthersan, 1993). For the purpose of the FS, it was assumed that the angle distribution would be 45 degrees; therefore, the radius of influence and the well screen depth are related in a 1:1 proportion.

Sparging in a pulsed mode ("on/off" manner) increases the effective radius of influence relative to what it would be if sparging were continuous (Boersma et. al, 1994). IAS causes flow paths which are initially water-filled to become air-filled. The resulting displacement results in groundwater flow away from the well (where the frequency of air-filled flow paths is greatest) and after initiation of air flow, and back toward the well after termination of air flow. The back and forth groundwater flow tends to increase the effective radius of sparging influence. It is assumed that pulsed operations would double the radius of influence.

Based on these assumptions and a radius of influence of 10.5 feet, the effective radius of influence would be 21 feet and the distance between sparging wells would therefore be 42 feet. Thus, based on a 21 foot effective radius of influence, a "5 x 5" pattern of 25 sparging wells placed on 42 foot centers are expected to provide adequate coverage for a 1-acre treatment area. This spacing dimension is within typical ranges for IAS systems, but should be refined with additional pilot testing, as appropriate. The plan view layout of such a 2 acre module is shown in Figure 6-7.

EXTRACTION

The radius of influence of each horizontal extraction well would depend largely upon the type of soil adjacent to the wells and the depth of each well. Given the shallow subsurface over much of the site is comprised of relatively impermeable fill over channel gravels, significant horizontal migration of vapors near the subsurface is possible and therefore the ROI of an extraction well could be significant. For FS design purposes, it is assumed that the effective ROI of the extraction wells is equivalent to that of the injection wells (21 feet). On the other hand, because the extraction wells are shallower than the injection wells, the ROI of the extraction wells could be smaller. The uncertainty in this assumption requires that, if selected, this alternative would need a pilot study to finalize vapor extraction well spacing.

ABOVE-GROUND PROCESS COMPONENTS

Key conceptual design components are defined in Table 6-2. The most critical above ground process component is the IAS blower, which provides adequate flow and pressure of air to the sparging points. It is assumed that that only half of the wells in a module would be operated a given point in time. Based on this assumption, 10 HP rotary vane blowers would be capable of providing air at 125 cfm or 5 cfm for each of 25 injection wells. In order to move air out the bottom of the well screen, the air pressure must be greater than the static pressure at the base of the well screen and the pressure losses in the piping. Based on a maximum of 18 feet of saturated thickness, an air pressure of at least 8 psi would be required to ensure that air is delivered to the base of the sparging wells during high groundwater occurrences. The rate of head loss in the piping system would vary depending on the joints, elbows, and valves used, but a general guideline for head loss is 0.5 psi/100 feet of pipe, which translates to a maximum of approximately 1.5 psi per module. Applying a safety factor of 1.3, blowers should be capable of producing a pressure of 12 psi.

A pilot study would be needed to refine the design of any SVE system; however certain assumptions were made about its design for the purpose of constructing the feasibility study. It is assumed that each SVE system would be composed of a 20 hp motor capable of powering a positive displacement blower and producing 10 inches of Hg vacuum at each extraction. Also, it is assumed that the majority of vapors would be captured by extracting air at a rate at least twice the rate of injection, or 10 scfm per injection well. With half of a module's injection wells (25) in operation at a given point in time, each SVE system would need to extract at a minimum of 250 scfm of air.

Each IAS blower and SVE system would be electrically powered and housed in a building (see Figure 6-7). Each system would be controlled on a single panel to reduce the cost of instrumentation and control switches. Also inside each building would be in-line pressure gauges and flow-meters, allowing monitoring of system performance.

IAS piping would be HDPE because of the significant heat generation from each blower; SVE piping would be PVC. It was assumed that connection piping would be buried 2 foot deep to prevent interruptions in site activity. Also, because some condensation may occur in pressurized lines, burying the pipe would help insulate and protect pipe walls. Each well's connection piping would have an in-line pressure gauge and flow-meter for monitoring system performance.

REMEDIATION TIME FRAME

Calculations for estimating the amount of treatment time required to achieve RAOs are presented in Appendix J. Based on these calculations, sparging treatment could be completed in 3 years. However, there is a good deal of uncertainty in the parameters used to develop this timeframe. A 3-year treatment time was assumed for the purpose of developing feasibility level cost estimates. Because the effectiveness of this technology is unknown (especially so given that no pilot tests have been completed for this site), it is feasible that the sparging time required to make significant advancement toward achievement of RAOs could be 10 years, with continued monitoring after that time.

A significant factor contributing to the uncertainty in achieving groundwater restoration is the "reverse diffusion" effect. Reverse diffusion is the slow release of aqueous phase COCs from any strata (e.g., the low permeability alpine clay) that has been in long term contact with the COC plume and/or DNAPL and which through the process of diffusion and sorption have become a significant source of non-DNAPL source mass. This is a topic that has seen attention in literature (Sudicky et al., 1985; Parker et al., 1993; Parker et al., 1997). The implications of non-DNAPL source mass are large because COC removal from non-DNAPL sources may become diffusion limited, rather than treatment limited.

6.4.2.2 South Plume Source Sparging

Sparging of the south plume source areas would be performed in a manner very similar to the north plume in terms of basic system components. The following discussion focuses on the differences.

The system is described in Table 6-3, and the system layout is shown in Figure 6-9. Key attributes to the south plume IAS system which are different from the north plume system are:

- The south plume treatment area module is capable of treating approximately 4 acres. 1.5-4 acre modules are anticipated as sufficient for treating these source areas.

- Based on the estimated saturated thickness of wells in the treatment area, the average ROI was assumed to be 15 feet and the effective ROI was assumed to be 30 feet (Figure 6-8). Based on these assumptions, it was assumed that sparging wells would be placed in a "5 x 5" pattern on 60 feet centers (Figure 6-9).

- The maximum saturated thickness of injection wells in the treatment area was estimated to be 21 feet. Based on this saturated thickness, an air pressure of approximately 9 psi would be required to push water out the base of the sparging well. Maximum head losses are estimate to be 2 psi. Applying a safety factor of 1.3, a blower pressure of 14 psi would be sufficient for each module.

- Given that the north plume generally has higher CVOC concentrations than the south plume, it is conservatively assumed that the remediation time for the south plume is equivalent to that of the north plume.

- It has been established that natural attenuation processes at the site have significantly limited migration of aqueous phase COCs. Key natural attenuation processes are believed to be reductive dechlorination of parent VOCs (e.g. TCE) in the heart of the plume, resulting in the production of vinyl chloride which is further dechlorinated to innocuous byproducts via anaerobic and/or aerobic biodegradation at the plume edge. Since air sparging in the heart of the plume will raise the oxidation-reduction potential of the source area, it is reasonable to assume that anaerobic natural attenuation processes in the heart of the plume may be adversely impacted by air sparging. Furthermore, given the potential for DNAPL pockets in the subsurface and/or reverse diffusion of VOCs from the clay layer to the groundwater, the effectiveness of air sparging on limiting plume migration is uncertain. Given these considerations, and the uncertainty in VOC removal rates that will be achieved with air sparging, there is also uncertainty as to whether or not air sparging will increase or decrease actual COC migration.

6.4.3 Cost Estimate

North and south plume costs estimates were created by developing an estimate for a module of the total system and then up scaling the modular cost over the whole treatment area. Based on this approach, the following modular costs were developed.

- A 2-acre module for the north plume is estimated to cost $390,000 (Appendix H).

- A 4-acre module for the south plume is estimated to cost $420,000 (Appendix H).

- For each module (independent of aerial extent), assuming 5 years of operations and a 7 percent interest rate, the present worth cost of operation and maintenance costs is estimated to be $240,000 (Appendix H).

Capital expenditures and operation and maintenance costs for the north and south plume sparging systems are summarized in Appendix H. A scaling factor was applied to "up-scaling" these modular systems because sparging on a large scale results may result in certain cost efficiencies (for example, bulk purchasing). The following costs reflect the potential for these cost efficiencies.

- North plume capital and operation and maintenance costs are estimated to be $1.85 million.
- South plume capital costs and operation and maintenance costs are estimated to be $842,000.

Based on the above, the total cost of this alternative (including IAS and MNA activities) is anticipated to be $3.31 million.

Please note that cost estimates were prepared solely for the purposes of comparing relative costs of various corrective action alternatives, and should not be used for budgetary purposes. IAS costs are particularly dependent on the spacing and configuration of the injection and extraction wells, parameters which are best determined through pilot testing.

6.5 ALTERNATIVE 5 – PERIMETER GROUNDWATER TREATMENT

This alternative adds a more aggressive site boundary remedial approach (air sparging wall) to the monitored natural attenuation alternative described in Section 6.3. By adding an even more aggressive site boundary remedial approach, the potential for CVOCs to impact nearby surface water in the Weber River might be reduced.

6.5.1 Concept

Several north plume monitoring wells located within 200 feet of the Weber River have detected vinyl chloride in groundwater, with concentrations ranging up to 86 ug/L. Additionally, the down gradient end of the plume extends toward the 21st Street Pond, a regional groundwater sink. The concern for potential plume migration into either water body exists, though vinyl chloride has not been detected in either the Weber River or the 21st Street Pond and the plume has likely reached its steady state extent. This alternative consists of installation of an IAS sparging wall along the edges and down gradient extent of the plume to contain the plume to the rail yard and prevent it from impacting receptors. An IAS sparging wall was selected as a representative barrier technology to determine if this type of approach provided any practical benefit at the site. This assumes that the general evaluation of an IAS sparging wall is essentially the same as for other barrier technologies relative to concept and effectiveness. If this representative approach is chosen, further optimization of the treatment approach would be included later. Evaluation of an

IAS wall in this FS also allows a consistent application of air-based technologies for aggressive source remediation and plume containment, simplifying the overall technology discussion.

Similar to the air sparging source treatment alternative, this alternative consists of installation of IAS systems to volatilize vinyl chloride and stimulate aerobic biodegradation in the saturated and unsaturated zones. To contain the plume, sparging wells would be placed in two locations (Figure 6-10).

- Along a 1050 ft. stretch roughly parallel to the Weber River and groundwater flow, approximately located between 34-MW8 and 34-OB-16.
- Along a 350 ft. length perpendicular to the direction of groundwater flow, approximately located between 34-OB-16 and 34-OB-12.

Geoprobe boring logs and monitoring well completion diagrams near the proposed walls were examined to determine if the subsurface geology is appropriate for an air sparging wall.[11] The groundwater bearing zone along the treatment wall is generally composed of permeable gravels and sands. Underlying the gravels and sands is the Alpine clay, which is estimated to be 12-20 ft. bgs. The soils above the clay layer should be amenable to transporting injected air from the well.

Walls would treat vinyl chloride in three basic ways.

- **Aerobic biodegradation in the saturated zone.** Though groundwater lost from the Weber River provides an influx of aerobic water, the oxygen flux is likely not large enough to satisfy oxygen demand far beyond the river's eastern edge.[12] Injection of air into the saturated zone would enhance oxygen transfer to groundwater and the rate of aerobic biodegradation in the saturated zone near the injection points.
- **Biodegradation of Vinyl Chloride in the Unsaturated Zone.** Vinyl chloride that partitions into injected air and oxygen that is not consumed in the saturated zone will be

[11] See well completion diagrams or boring logs for 34-MW2, 34-MW8, 34-MW9, 34-B7, 34-B30, 34-B31, 34-B32, 34-B69, 34-B70, 34-B72, and 34-B73.

[12] Groundwater samples collected in monitoring wells nearest to the Weber River (for example, 34-MW9) consistently detected low concentrations of dissolved oxygen and elevated levels of dissolved iron.

transported to the vadose zone, where vinyl chloride would continue to be aerobically biodegraded.

- **Volatilization.** IAS induced volatilization will likely be the major process by which vinyl chloride is removed. Given the relatively low levels of vinyl chloride that exist in groundwater along the sparging wall, the mass flux of CVOCs to the surface is anticipated to be small. As CVOCs are transported into the vadose zone, some may continue to migrate vertically to the surface where they would be diluted in the atmosphere and degraded by photo oxidization. Near the area where the sparging wall has been proposed, there are no known conduits or buildings where CVOCs could possibly pose a risk to rail yard workers. Based on these facts, it is assumed that an SVE system to collect CVOC vapors is not required for this alternative.

6.5.2 Conceptual Design

The process of conceptually designing an IAS wall is similar to that for applying IAS to source treatment. This section focuses on the main differences or additional factors in designing the IAS sparging wall.

Please note that this conceptual design was prepared for the purposes of developing "order of magnitude" cost estimates, appropriate for comparing the relative costs of alternatives. Should this alternative be selected for implementation, the design would need to be refined and revised as appropriate.

WELL DESIGN AND SATURATED THICKNESS

Along the proposed wall, the water table is encountered at 6-10 ft. bgs in a layer of alluvial sands and gravels. Under this layer is the Alpine Clay formation that is believed to underlie the whole site. The depth to clay is estimated to be 12-19 ft. below grade.

Shallow/deep well pairs in other areas of the north plume show that groundwater is impacted throughout the gravel layer. Based on samples from these wells, it is assumed that all shallow groundwater at the plume edges is also impacted. Sparging wells would therefore be screened at the top of the clay layer. For the purpose of developing a conceptual design of this alternative, the average depth to clay was assumed to be 17 ft.

Water level data from seven monitoring wells located near the proposed location of the sparging wall were examined to estimate saturated thickness. The average saturated zone thickness is estimated to range from 6-11 feet, and water levels generally fluctuated within 2 feet of the average. Based on this analysis, an average saturated thickness of 8 ft. was assumed in the conceptual design.

WELL SPACING

The appropriate spacing for IAS wells is best determined through pilot testing. For the purposes of the FS, well spacing was estimated to generate a useable cost estimate for cost comparison with other feasibility study alternatives.

Conceptually, the shape of the area treated by a sparging well is that of an inverted cone that extends from the bottom of the sparging well to the water table (Figure 6-11). To effectively treat all groundwater that passes between two sparging wells, wells must be spaced at half their effective radius of influence. Otherwise, half of the water passing between the wells is essentially untreated.

To ensure that the majority of groundwater passing through the wall would be treated, it was assumed the piping and well configuration would consist of two rows of wells. The first row's wells would be placed on 32 ft. centers along a manifold pipe.[13] The second line of wells would also be placed at 32 ft. centers, but wells would be placed at the midpoint between first row wells and offset 16 ft. This configuration also provides a degree of reliability over a configuration where all the wells are placed in series along a single manifold pipe (that is, if the only manifold pipe was damaged, sparging performance in all wells would be affected). Layout of one segment of the treatment walls is shown in Figure 6-12.

[13] Assuming that the radius of influence and the average saturated thickness are related in a 1:1 relationship, the radius of influence is assumed to be 8 ft. Assuming that pulsed operation effectively doubles the radius of influence, wells along one line would be placed on 32 ft. centers. This is within typical ranges for IAS systems, but should be refined with pilot testing if this alternative is selected.

For the purpose of developing a feasibility study cost estimate, it was assumed that the treatment wall would be composed of four segments and that each segment would be capable of treating 310 ft. or more of length. It was assumed that three segments would be composed of 21 wells, and that one segment would be composed of 22 wells.

ABOVE-GROUND PROCESS COMPONENTS

Key design parameters for the IAS wall are provided in Table 6-4. 10 HP blowers would be capable of providing air at 110 cfm or a minimum of 5 cfm for each of the wells. Based on a maximum of 12 feet of saturated thickness, an air pressure of at least 5 psi would be required to ensure that air is delivered to the base of the sparging wells during high groundwater occurrences. The rate of head loss in the piping system would vary depending on the joints, elbows, and valves used, but using a general guideline for head loss of 0.5 psi/100 feet of pipe, a maximum of approximately 1.5 psi per segment. Applying a safety factor of 1.3, blowers should be capable of producing a pressure of 9 psi.

Each blower would be electrically powered and housed in a building. For the purpose of this design, it was assumed that in most cases one blower could be housed in each building (see Figure 6-12). Blowers would run continually and would be alternated between wall segments, such that each blower would be connected to one 350' wall segment at a time. Each blower would be controlled on a panel in its respective building. Also, inside each building would be in-line pressure gauges and flow-meters.

Piping would be stainless steel because of the significant heat generation from each blower. It was assumed that connection piping would be buried 1 foot deep to prevent interruptions in site activity and to help insulate and protect pipe walls. Each well's connection piping would have an in-line pressure gauge and flow-meter for monitoring system performance.

6.5.3 Cost Estimate

A cost estimate was developed for the two treatment walls based on the conceptual layout described above.

- Capital costs for the treatment walls are estimated to be $790,000. (Appendix H).

- Assuming 30 years of operations and a 7 percent interest rate, the present worth cost of operation and maintenance costs is estimated to be $1.02 million. (Appendix H).

Based on the above, the present value of installing an air sparging barrier wall for the north plume, including costs for MNA activities, is estimated to be $2.36 million.

Please note that cost estimates were prepared solely for the purpose of comparing relative costs of various corrective action alternatives, and should not be used for budgetary purposes. IAS costs are particularly dependent on the spacing and configuration of the injection wells, parameters which are best determined through pilot testing.

6.6 ALTERNATIVE 6 – AGGRESSIVE SOURCE AREA REMEDIATION AND ACTIVE GROUNDWATER REMEDIATION

This alternative adds an even more aggressive source area remedial approach (plume-wide air sparging) to the monitored natural attenuation alternative and focused source area treatment described in Section 6.4. By adding an even more aggressive plume-wide remedial approach, it was believed that overall remediation times might be reduced even further, compared to monitored natural attenuation and focused source area treatment.

6.6.1 Concept

This alternative is similar to Alternative 4, but consists of placing sparging wells into the areas where dissolved concentrations CVOCs have been measured above the risk-based screening levels for CVOCs, as opposed to high-concentration source areas only. As IAS depletes the dissolved plume mass, VOC groundwater concentrations will decrease. In theory, continued treatment would remediate the groundwater to concentrations below site screening levels. The overall goal of this alternative would be to treat the dissolved plume area above risk-based screening levels.

6.6.2 Conceptual Design

Figures 6-13 and 6-14 show the areas where source zone sparging would occur in the north and south plumes respectively. Sparging would occur in two areas.

- In the north plume, over a 50 acre area.
- In the south plume, over a 24 acre area.

The conceptual design of the IAS system considered the following key components.

- Well design and saturated thickness.
- Well spacing.
- Above-ground process components.

For the purpose of the FS, a modular approach was assumed. Please note that this conceptual design was prepared for the purposes of developing "order of magnitude" cost estimates, appropriate for comparing the relative costs of alternatives. In the event that this alternative would be selected for implementation, the design would need to be refined and revised as appropriate.

Like alternative 4, there is substantial uncertainty to the amount of time required for this alternative to achieve RAOs. It is likely that that the areas with highest groundwater concentrations will require the longest treatment times; therefore, it is assumed that the total operational time for this alternative is similar to Alternative 4. Given the large degree of uncertainty, it is possible that aggressive IAS could be performed for 10 years with continued monitoring after that time. Furthermore, as discussed previously, the reverse diffusion phenomenon adds considerable uncertainty to the time required to achieve groundwater restoration.

6.6.2.1 *Northern Plume Sparging*

Sparging of the north plume source areas would be performed in a manner very similar to the sparging north "source" area in terms of basic system components (Section 6.4.2.1).

The system is described in Table 6-2, and the system layout is shown on Figure 6-13. The north dissolved plume treatment area module is capable of treating approximately 2 acres. Twenty-five 2-acre modules are anticipated as sufficient for treating the dissolved plume area.

6.6.2.2 South Plume Sparging

Sparging of the south plume source areas would be performed in a manner very similar to the south source area in terms of basic system components (Section 6.4.2.2).

The system is described in Table 6-3, and the system layout is shown in Figure 6-14. The south plume treatment area module is capable of treating approximately 4 acres. Six 4-acre modules are anticipated as sufficient for treating the dissolved plume area.

6.6.3 Cost Estimate

North and south entire-dissolved plume cost estimates were created by developing an estimate for a module of the total system and then up scaling the modular cost over the whole treatment area. Based on this approach, the following modular costs were developed.

- Each 2-acre modules for the north plume are estimated to cost $390,000 (Appendix H).
- Each 4-acre modules for the south plume are estimated to cost $420,000 (Appendix H).
- For each module (independent of aerial extent), assuming 5 years of operations and a 7 percent interest rate, the present worth cost of operation and maintenance costs is estimated to be $240,000 (Appendix H).

Capital expenditures and operation and maintenance costs for the north and south entire dissolved plume sparging systems are summarized in Appendix H. A scaling factor was applied to up-scaling these modular systems because sparging on a large scale results may result in certain cost efficiencies (for example, bulk purchasing). The following costs reflect the potential for these cost efficiencies.

- North plume capital and operation and maintenance costs are estimated to be $4.3 million.
- South plume capital costs and operation and maintenance costs are estimated to be $1.9 million.

Based on the above, the total cost of air sparging the north and south plume source areas, including sampling and reporting, is anticipated be $6.9 million.

Please note that cost estimates were prepared solely for the purposes of comparing relative costs of various corrective action alternatives, and should not be used for budgetary purposes. IAS costs are particularly dependent on the spacing and configuration of the injection and extraction wells, parameters which are best determined through pilot testing.

7 DETAILED ANALYSIS OF ALTERNATIVES – RAIL YARD GROUNDWATER OPERABLE UNIT

This section includes a detailed analysis of the Ogden Rail yard Groundwater alternatives to be considered (Table 7-1). The detailed analysis is a multi-step process of evaluating alternatives to allow comparison of the alternatives and to identify the key trade-offs among them. During the detailed analysis, each alternative is assessed against the evaluation criteria described in the Sections 4.1 through 4.3. The results of the detailed analysis, shown in Table 7-1 and discussed below, provide relevant information needed to allow selection of the site remedy.

7.1 COMPARATIVE ANALYSIS

A detailed comparative analysis is shown in Table 7-1. Alternative 1 does not meet any of the RAOs, and therefore is not discussed below. The main points of how alternatives compare to each other are discussed below.

7.1.1 Overall Protection of Human Health and the Environment

- Alternatives 2 through 6 all use ICs to prevent unacceptable exposure risk to current and future human populations presented by direct contact, inhalation, and ingestion of contaminated groundwater.

- Monitoring data and calculations indicate the CVOC plumes are not migrating or expanding due to natural attenuation, and natural attenuation should be sufficient to prevent future plume migration. Alternatives 2 through 6 all include continued monitoring to demonstrate that the plumes are not migrating. Alternative 5 provides a sparging wall as additional protection against downgradient migration into the Weber River and 21st Street Pond; this protection will not be necessary if the plume behaves as expected.

- The Forrester Group is not aware of any site with extensive chlorinated solvent impacts where groundwater restoration to MCLs has been achieved and documented. As such, there is significant uncertainty as to the time required for each of the alternatives to achieve MCLs.

- Alternatives 2 through 6 all treat and remove sources of ongoing groundwater contaminant loading, but differ in degree of source removal. EPA states in its technical directive on MNA that it *"expects that source control measures will be evaluated for all contaminated sites and that source control measures will be taken at most sites where practicable."* Removal of the sewer pipe sludge in Alternatives 3 is a source removal option that removes or immobilizes to the extent practicable a potentially significant source. Aggressive source area treatment likely reduces the time required to achieve site restoration of MCLs, but there is much uncertainty regarding the magnitude of the reduction.

7.1.2 Compliance with ARARs

- Alternatives 2 through 6 would meet action specific and location specific ARARs by design.

- As discussed in Appendix F, site conditions are appropriate for applying ACLs as the chemical-specific ARARs for groundwater at this site. With Alternatives 2 through 6, compliance with ACLs could be quickly demonstrated.

7.1.3 Long-Term Effectiveness and Permanence

- Residual risks would be eventually be reduced to below acceptable level (for example, MCLs will eventually be achieved) with Alternatives 2 through 6.

- In the long term, all the alternatives may require the same degree of monitoring.

- Alternatives 2 through 6 all include monitoring to demonstrate compliance and institutional controls to prevent groundwater exposure. IAS has been proven to remove CVOCs. However, there is some data suggesting that free-phase chlorinated solvents may exist at the site, but if it does exist it is likely in small pockets that would defy practical delineation and remediation efforts. Reverse-diffusion from non-DNAPL source mass may adds additional uncertainty to the remediation timeframe. Thus, there is considerable uncertainty as to the timeframe that would be required to restore the impacted zone to drinking water quality criteria.

7.1.4 Reduction in Toxicity, Mobility, or Volume

- Alternatives 2 through 6 all reduce toxicity, mobility, and volume of contaminated groundwater, but not to the same degree or level.

7.1.5 Short-Term Effectiveness

- Based on its technical directive on MNA, EPA expects *"MNA will be an appropriate remediation method only where its use will be protective of human health and the environment and* ***it will be capable of achieving site-specific remediation objectives within a timeframe that is reasonable compared to other alternatives****"* (emphasis added). Alternatives 2 and 3 achieve all the remedial action objectives in a short time period, with the exception of restoration of groundwater to beneficial uses (that is, to drinking water quality criteria), which will likely take a very long period of time. While alternatives requiring more intensive source removal and/or groundwater remediation would likely reduce the period of time for the impacted groundwater zone to be restored, the magnitude of the reduction cannot be predicted with any certainty. Regardless of the timeframe, a considerable degree of protection of human health and the environment is provided during that timeframe by monitoring and institutional controls. The protection provided by these institutional controls should be considered, along with other factors, in the determination of "reasonable timeframe" for Alternative 2, 3, and 5 relative to Alternative 4.

7.1.6 Implementability

- Alternative 2 through 6 are all readily implementable.

7.1.7 Cost

- Natural attenuation alone (Alternative 2) is the least cost alternative.

- For an additional $390,000, a significant potential source of the north plume can be removed and/or immobilized (Alternative 3).

- If more upfront investment reduces the present worth cost, then the investment in reducing timeframe is worthwhile. However, the uncertainty in the reduction in timeframe with aggressive treatment is uncertain, and therefore any reduction in present worth cost is uncertain. The present worth value of aggressive treatment is more than 3 times that of focused source removal, indicating upfront investment is unlikely to lead to savings. In fact the uncertainty in timeframe would almost certainly increase, not decrease, the present worth value cost of aggressive treatment options.

8 CONCLUSIONS AND RECOMMENDATIONS - RAIL YARD GROUNDWATER OPERABLE UNIT

Based on the comparative analysis performed in Section 7.1, key remedy selection considerations are as follows:

- Natural attenuation processes at the site are very significant in limiting plume migration, providing complete dechlorination of chlorinated solvent constituents to innocuous byproducts, and even in reducing plume extent (as data for the South VOC plume suggests). The UPRR project team is unaware of a single site in the country where natural attenuation processes are performing any better with respect to control of chlorinated solvent plume migration. The site is an ideal candidate for a groundwater remedial action approach that incorporates MNA as a key component.

- Sludge in abandoned sewer lines appears to be a source of continued contaminant loading to the northern CVOC plume. Cleaning and/or grouting and capping of the sewer lines coupled with removal of contaminated soil (to be identified) is a cost-effective source control measure. The effectiveness of more intensive source control efforts is uncertain, particularly if there are any small pockets of free-phase chlorinated solvents present (as suggested by some of the data) and given the reverse diffusion phenomenon.

- There is no clear advantage in the ability of aggressive remediation options to achieve the RAOs compared to Alternative 3. All of the alternatives (except the No Action alternative) are capable of achieving all the RAOs in a short time period, except the RAO of restoring the groundwater to beneficial uses (as technically practicable).

- The timeframe for groundwater restoration with MNA is reasonable compared to aggressive groundwater treatment. Aggressive source area treatment likely reduces the time required to achieve site restoration, but there is much uncertainty regarding the magnitude of the reduction.

- The timeframe for groundwater restoration with MNA and focused removal is reasonable compared to MNA with aggressive source removal. Spending a substantial amount more for aggressive treatment is not appropriate given the ability of Alternative 3 to achieve all the other RAOs, and the uncertainty in the ability of aggressive removal options to achieve meaningful source removal and shortened cleanup times.

In summary, the recommended alternative (Alternative 3) consists of the following:

- Institutional controls will be used to prevent future exposure to contaminated groundwater.
- Monitored natural attenuation will be used to monitor the plume and ensure that the plume is not migrating and that surface waters are protected.
- Focused source removal will be performed to remove a significant source of groundwater contamination. Focused source removal will consist of cleaning, partial removal, and capping the former industrial sewer lines that run over the northern plume. If the integrity of the lines is not sufficient for cleaning, then the sections of the lines with questionable integrity will be removed along with contaminated soil and bedding to the extent practicable.

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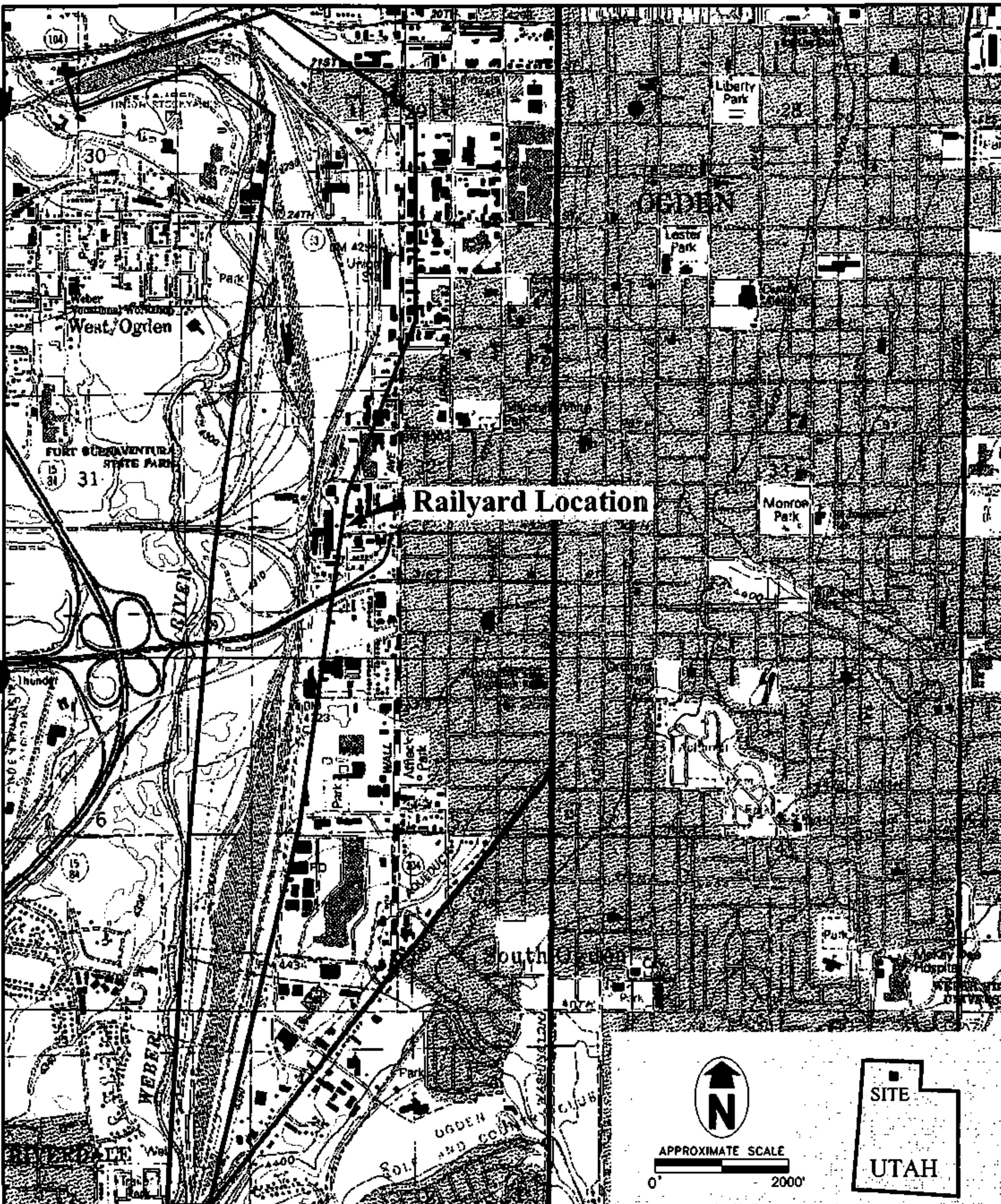
USEPA, 1988, Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, EPA/540/G-89/004, October 1998.

FIGURES



THE FORRESTER GROUP
INSIGHTFUL ENVIRONMENTAL SOLUTIONS™

TITLE:

FIGURE 1-1
RAIL YARD LOCATION MAP

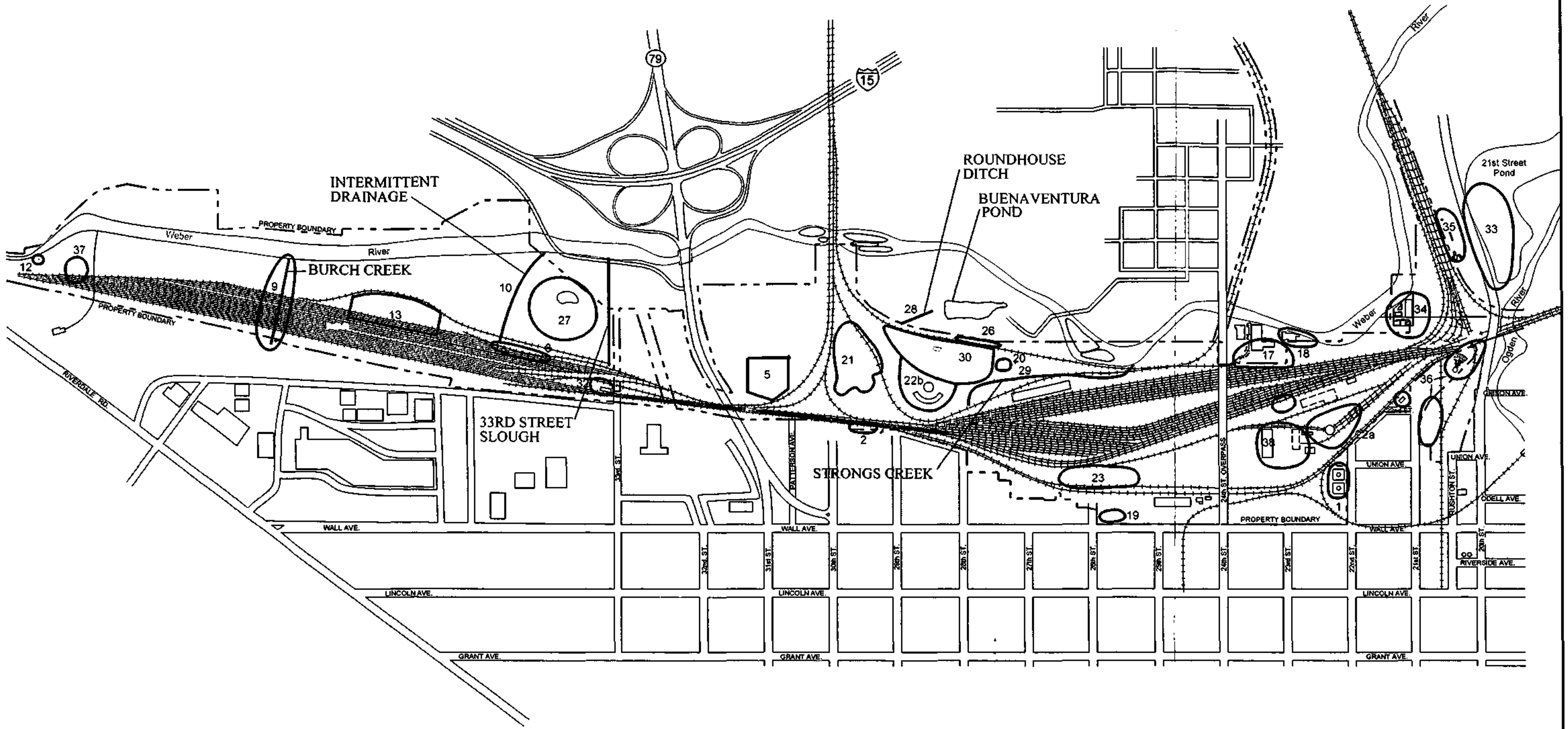
UNION PACIFIC RAILROAD FACILITY
OGDEN, UTAH

1330-Loc.dwg 2452915.41660441

Color Map(s)

The following pages contain color that does not appear in the scanned images.

To view the actual images, please contact the Superfund Records Center at (303) 312-6473.



LEGEND

RI/FS Site Boundary

30 RI/FS Area of Interest

Surface Water Feature

APPROXIMATE SCALE

0' 1200'

THE FORRESTER GROUP

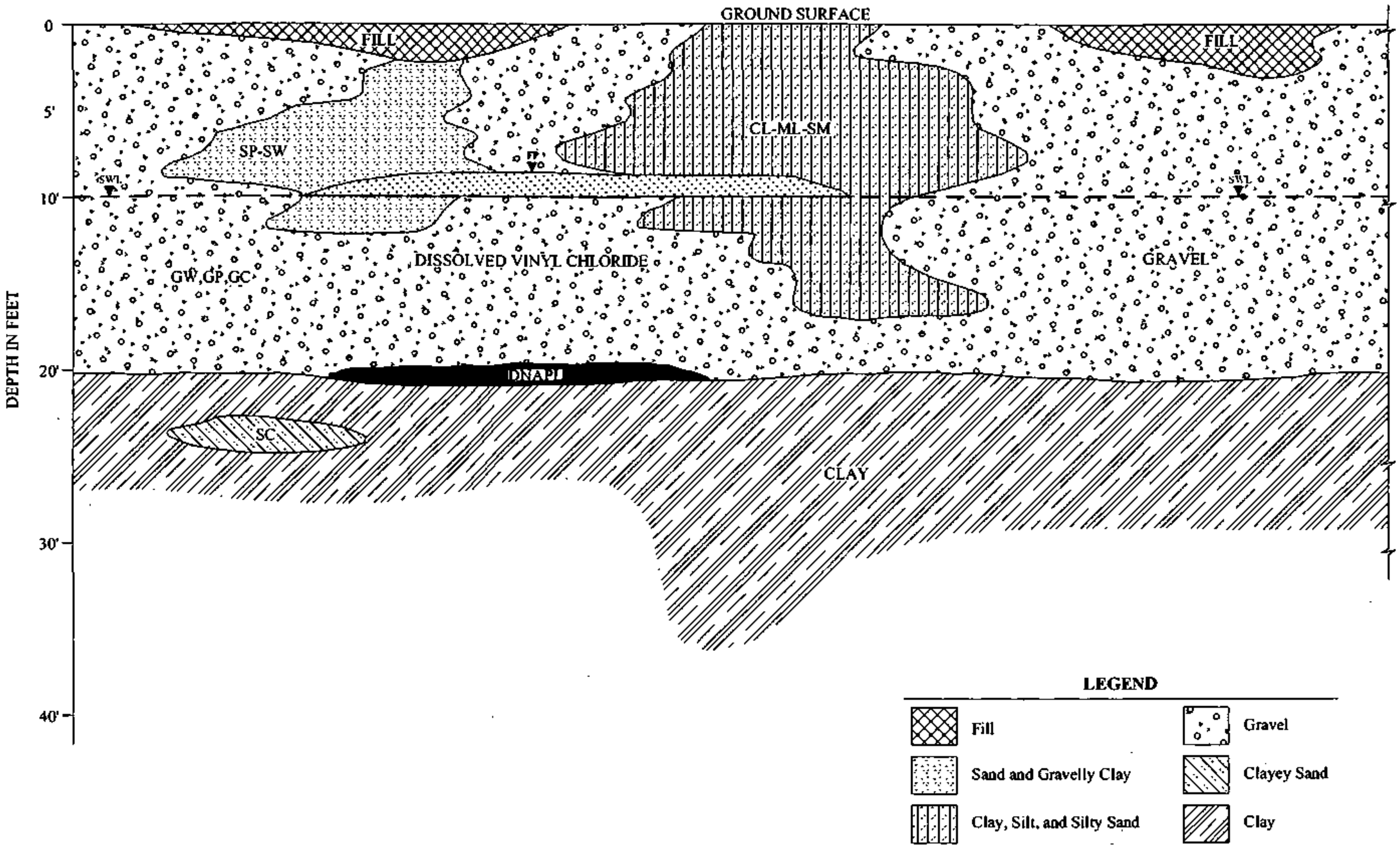
INSIGHTFUL ENVIRONMENTAL SOLUTIONS™

TITLE:

FIGURE 1-2
SURFACE WATER FEATURES

UNION PACIFIC RAILROAD FACILITY
OGDEN, UTAH

1330-X5.dwg 2453277.77361673



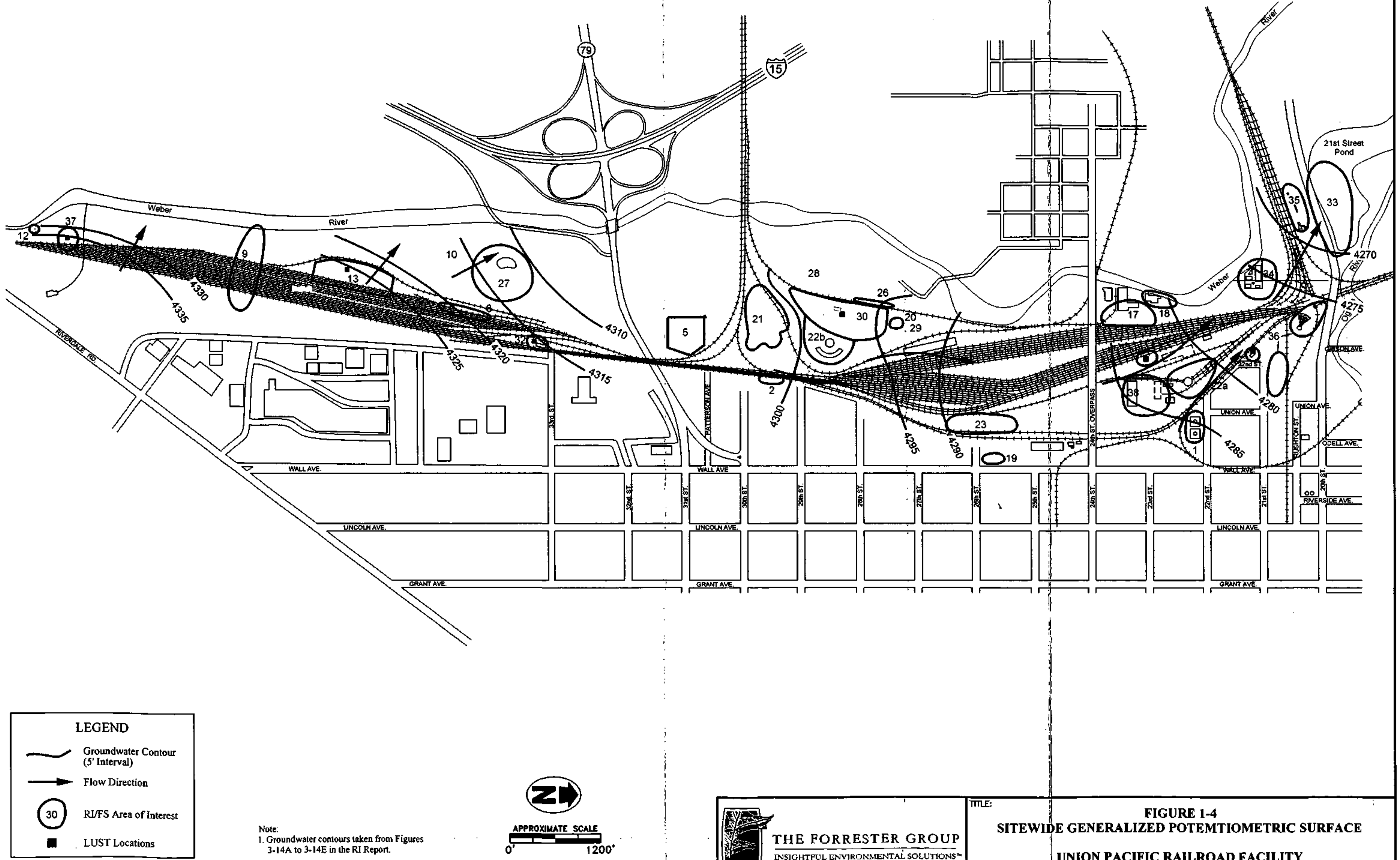
THE FORRESTER GROUP

INSIGHTFUL ENVIRONMENTAL SOLUTIONS™

TITLE:

FIGURE 1-3
REPRESENTATIVE SECTION OF ALLUVIAL STRATIGRAPHY
UNION PACIFIC RAILROAD FACILITY
OGDEN, UTAH

1330-X2.dwg 2453272.46275699



Note:
1. Groundwater contours taken from Figures 3-14A to 3-14E in the RI Report.

THE FORRESTER GROUP
INSIGHTFUL ENVIRONMENTAL SOLUTIONS™

TITLE:

FIGURE 1-4
SITEWIDE GENERALIZED POTEMTIOMETRIC SURFACE

UNION PACIFIC RAILROAD FACILITY
OGDEN, UTAH

1330-X5.dwg 2453277.77361673

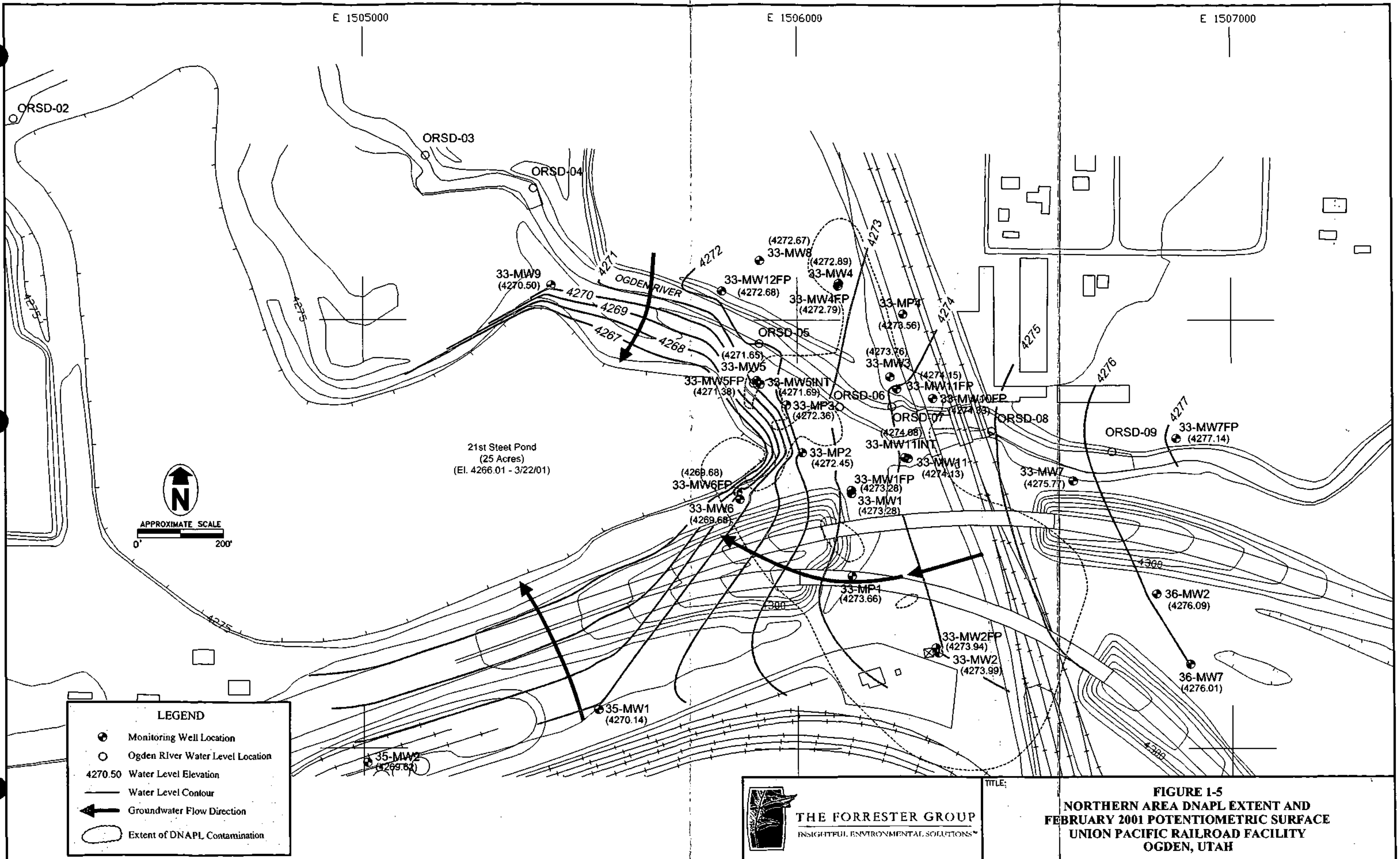
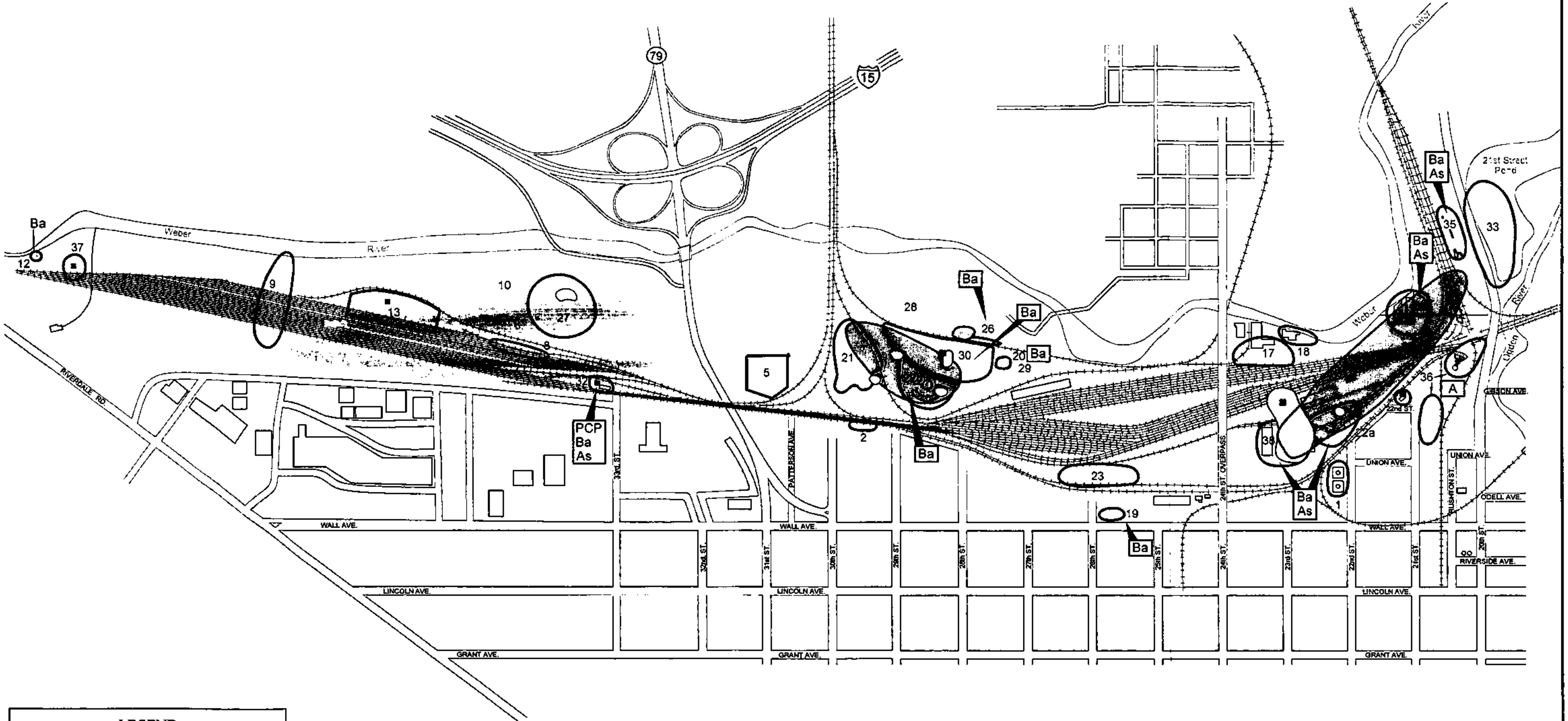


FIGURE 1-5
NORTHERN AREA DNAPL EXTENT AND FEBRUARY 2001 POTENTIOMETRIC SURFACE
UNION PACIFIC RAILROAD FACILITY
OGDEN, UTAH

1330-X7.dwg 2453271.69968829



LEGEND

30 RI/FS Area of Interest

■ LUST Locations

CONTAMINANT PLUMES

CVOC Plume

LNAPL Plume

PARAMETER EXCEEDING SCREENING LEVEL

Ba	Barium
As	Arsenic
PCP	CVOC Plume

N

APPROXIMATE SCALE

0' 1200'

THE FORRESTER GROUP

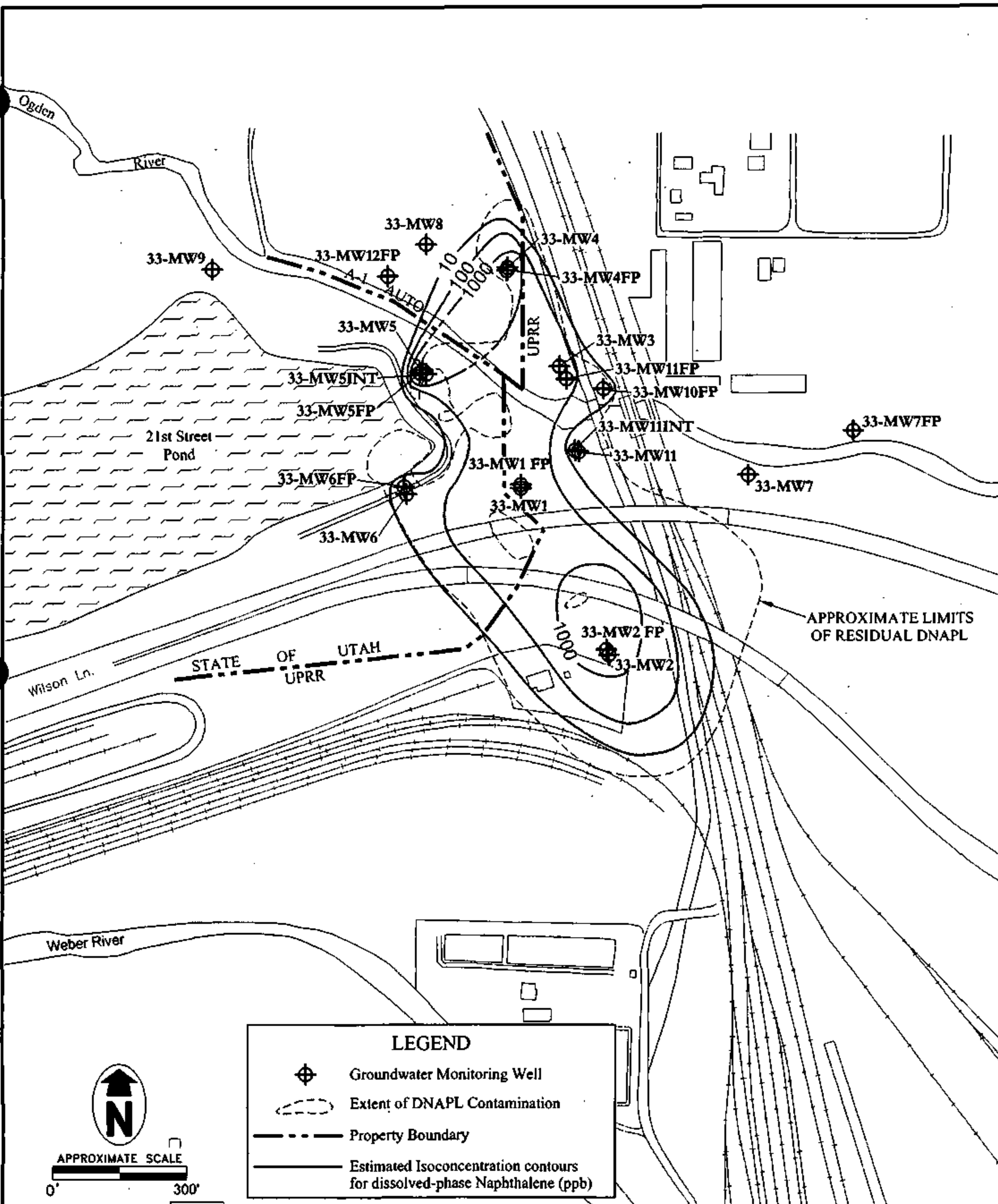
INSIGHTFUL ENVIRONMENTAL SOLUTIONS™

TITLE:

FIGURE 1-6
DISTRIBUTION OF GROUNDWATER IMPACTS

UNION PACIFIC RAILROAD FACILITY
OGDEN, UTAH

1330-X5.dwg 2453277.77361673



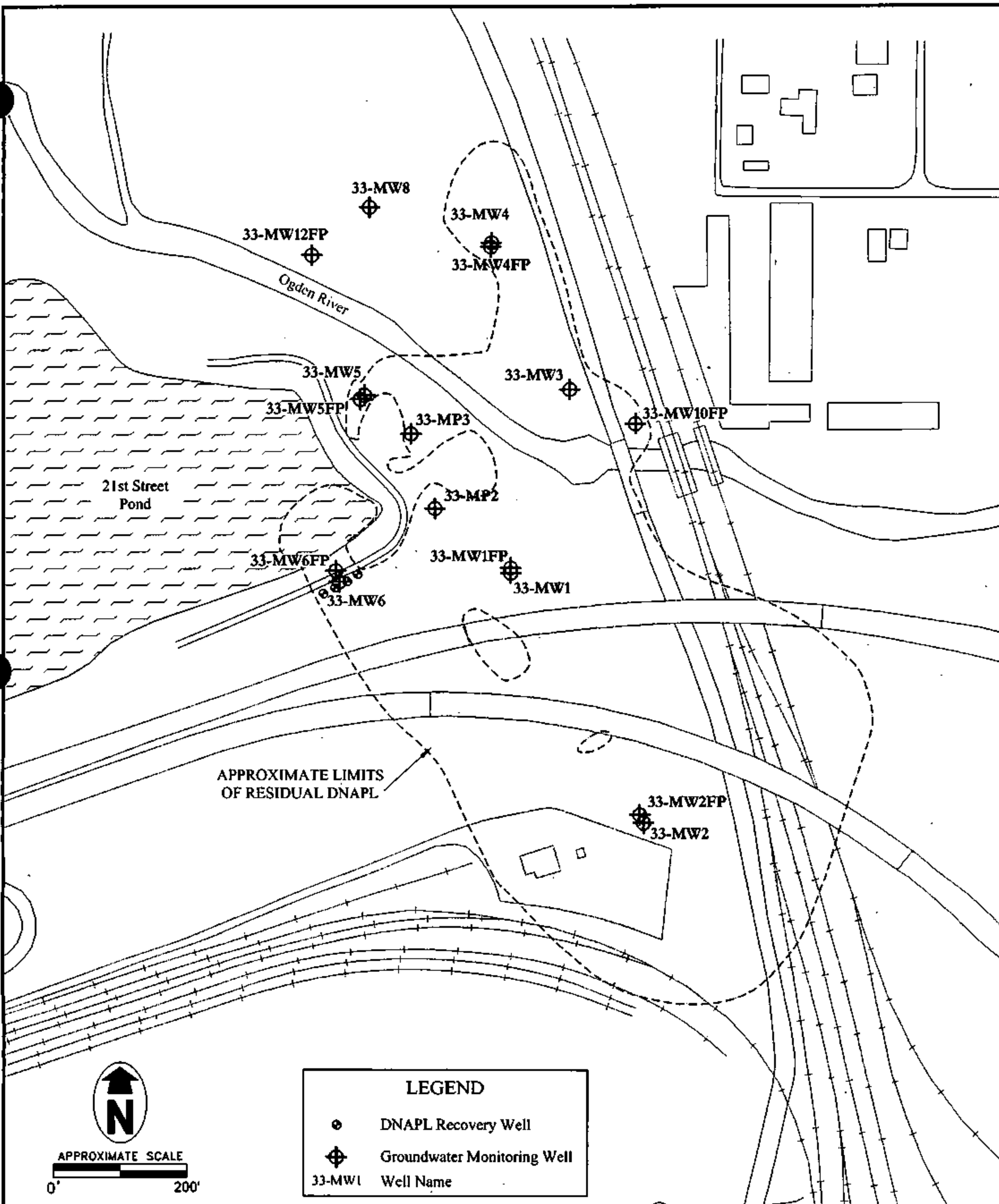
THE FORRESTER GROUP
INSIGHTFUL ENVIRONMENTAL SOLUTIONS™

TITLE:

FIGURE 1-7
DISTRIBUTION OF DISSOLVED PHASE PAHs

UNION PACIFIC RAILROAD FACILITY
OGDEN, UTAH

1330-X1.dwg 2452935.34786677



THE FORRESTER GROUP

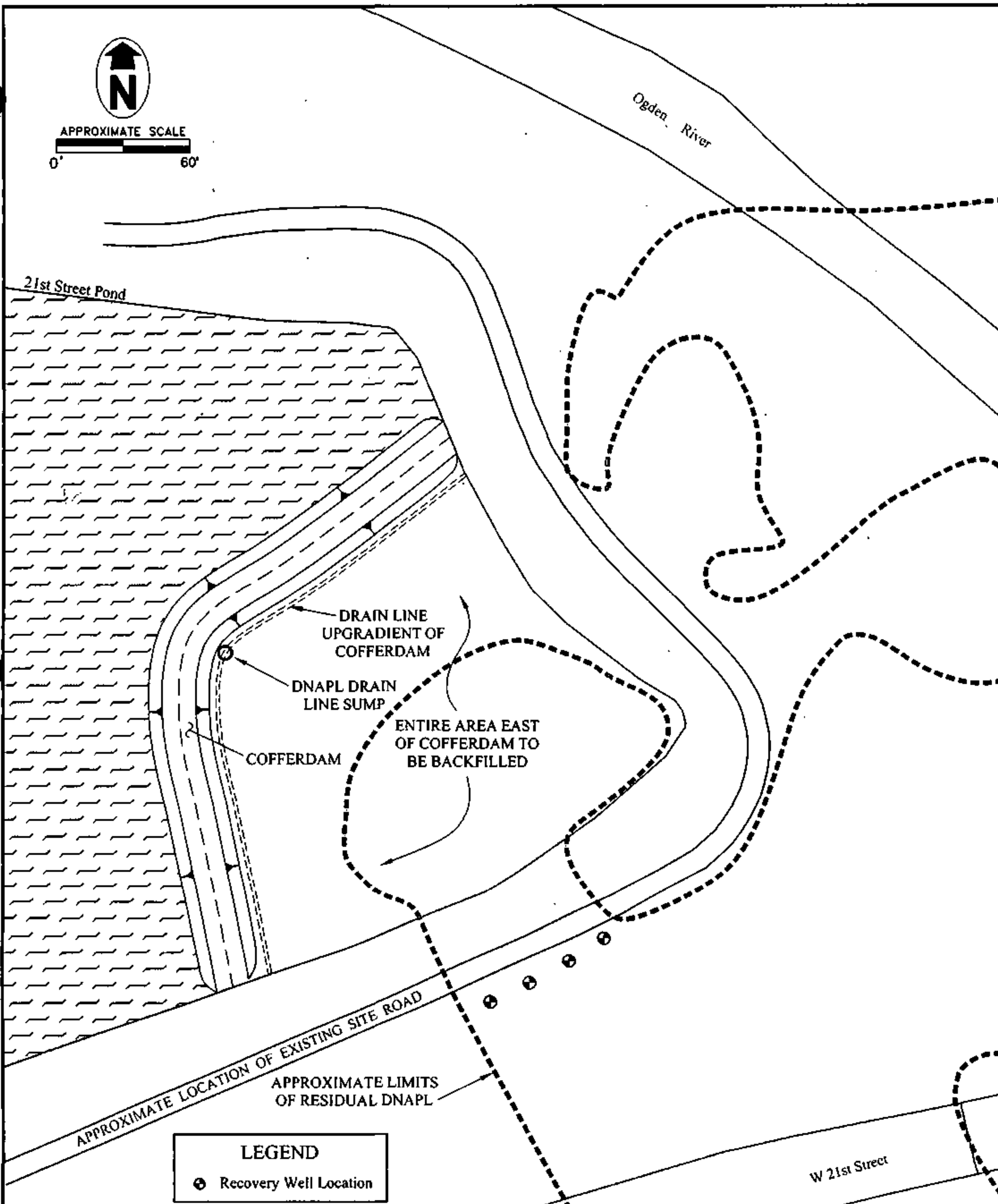
INSIGHTFUL ENVIRONMENTAL SOLUTIONS™

TITLE:

FIGURE 3-1
DNAPL MONITORING NETWORK

UNION PACIFIC RAILROAD FACILITY
OGDEN, UTAH

1330-X1.dwg 2452934.48127182



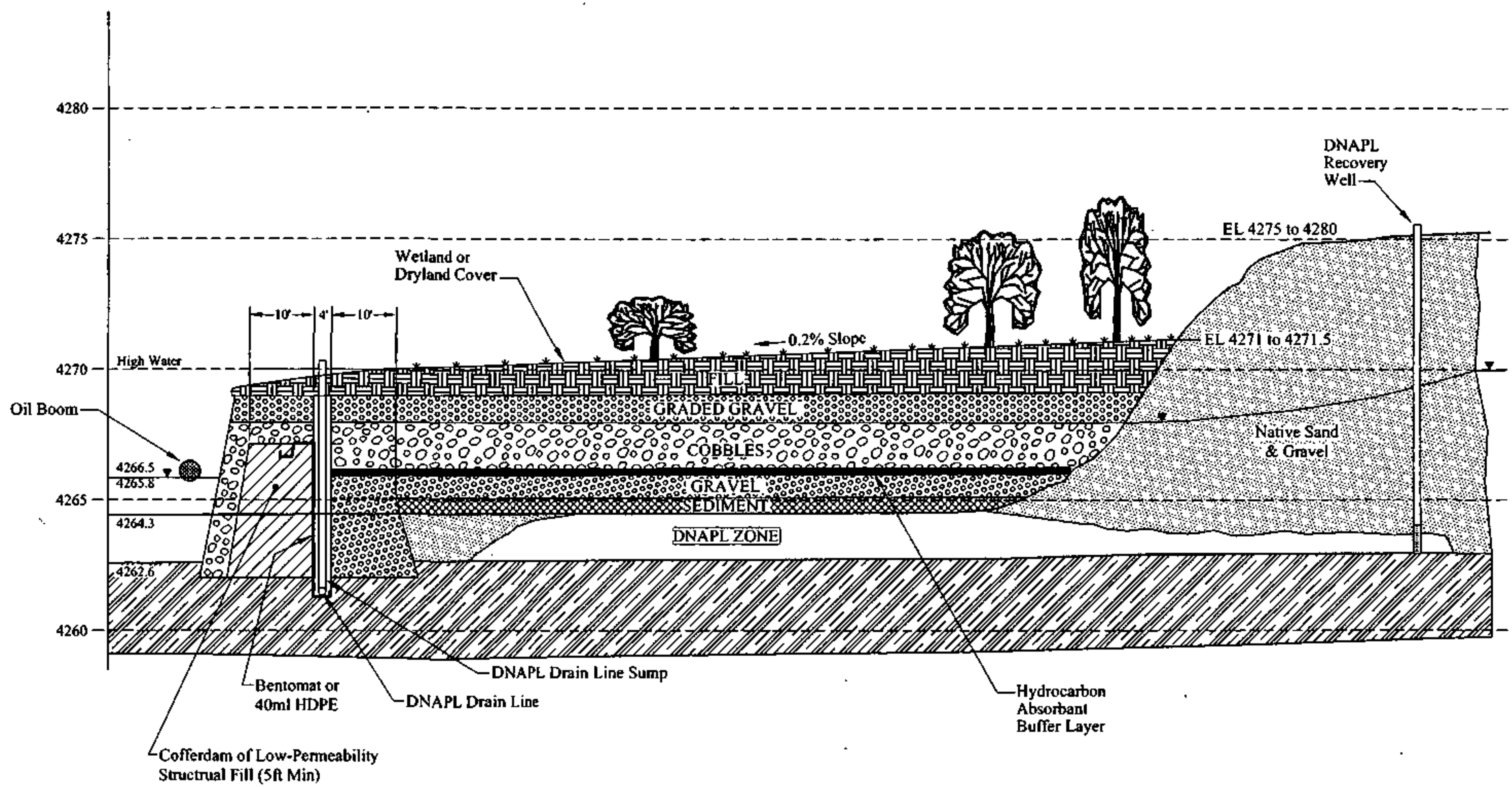
THE FORRESTER GROUP

INSIGHTFUL ENVIRONMENTAL SOLUTIONS™

TITLE:

FIGURE 3-2
PLAN OF POND SEDIMENT CONTAINMENT AREA
UNION PACIFIC RAILROAD FACILITY
OGDEN, UTAH

1330-X1.dwg 2452985.71870331



THE FORRESTER GROUP

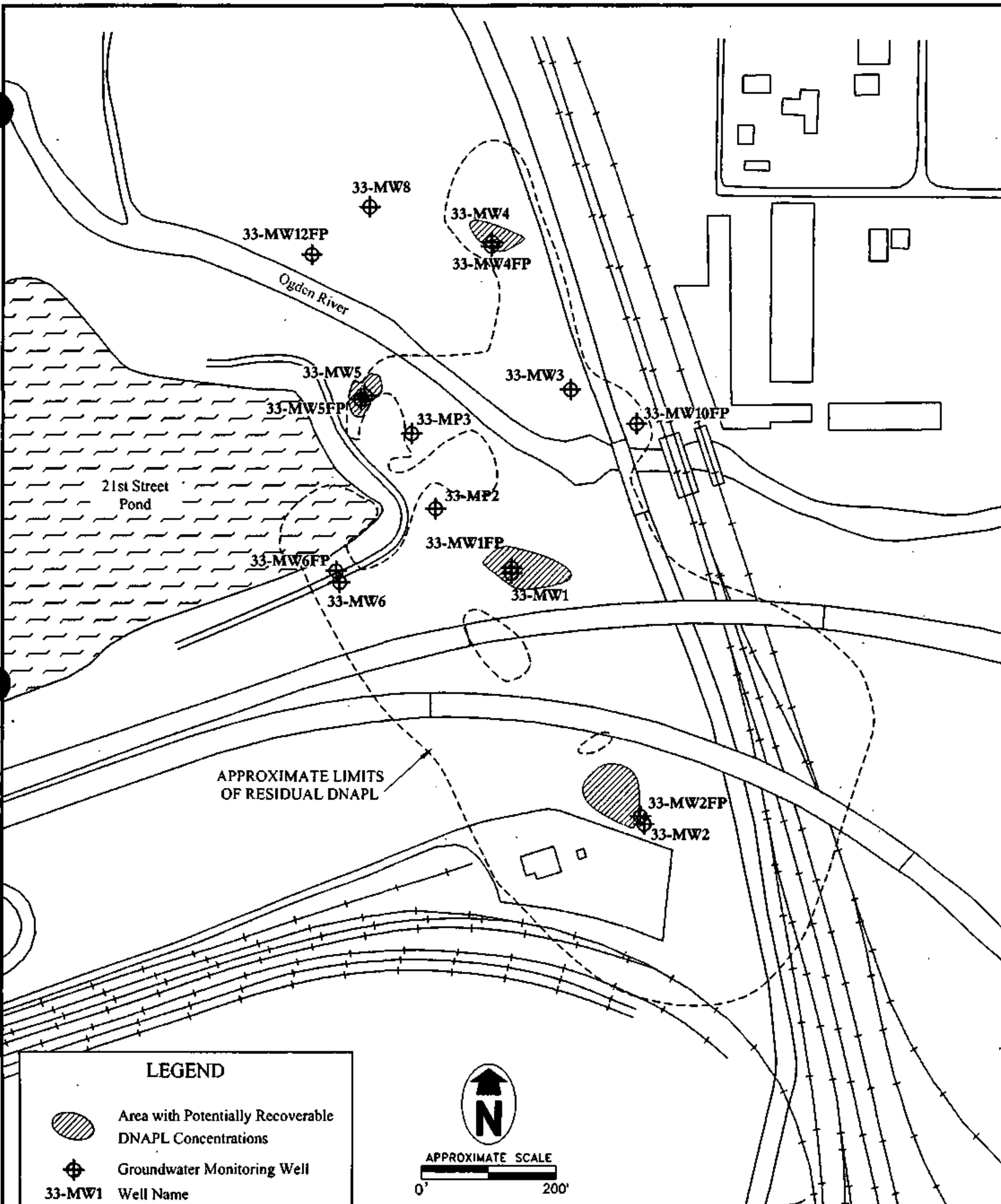
INSIGHTFUL ENVIRONMENTAL SOLUTIONS™

TITLE:

FIGURE 3-3
CROSS-SECTION OF CONTAINMENT AREA

UNION PACIFIC RAILROAD FACILITY
OGDEN, UTAH

1330-X3.dwg 2452949.43518779



THE FORRESTER GROUP

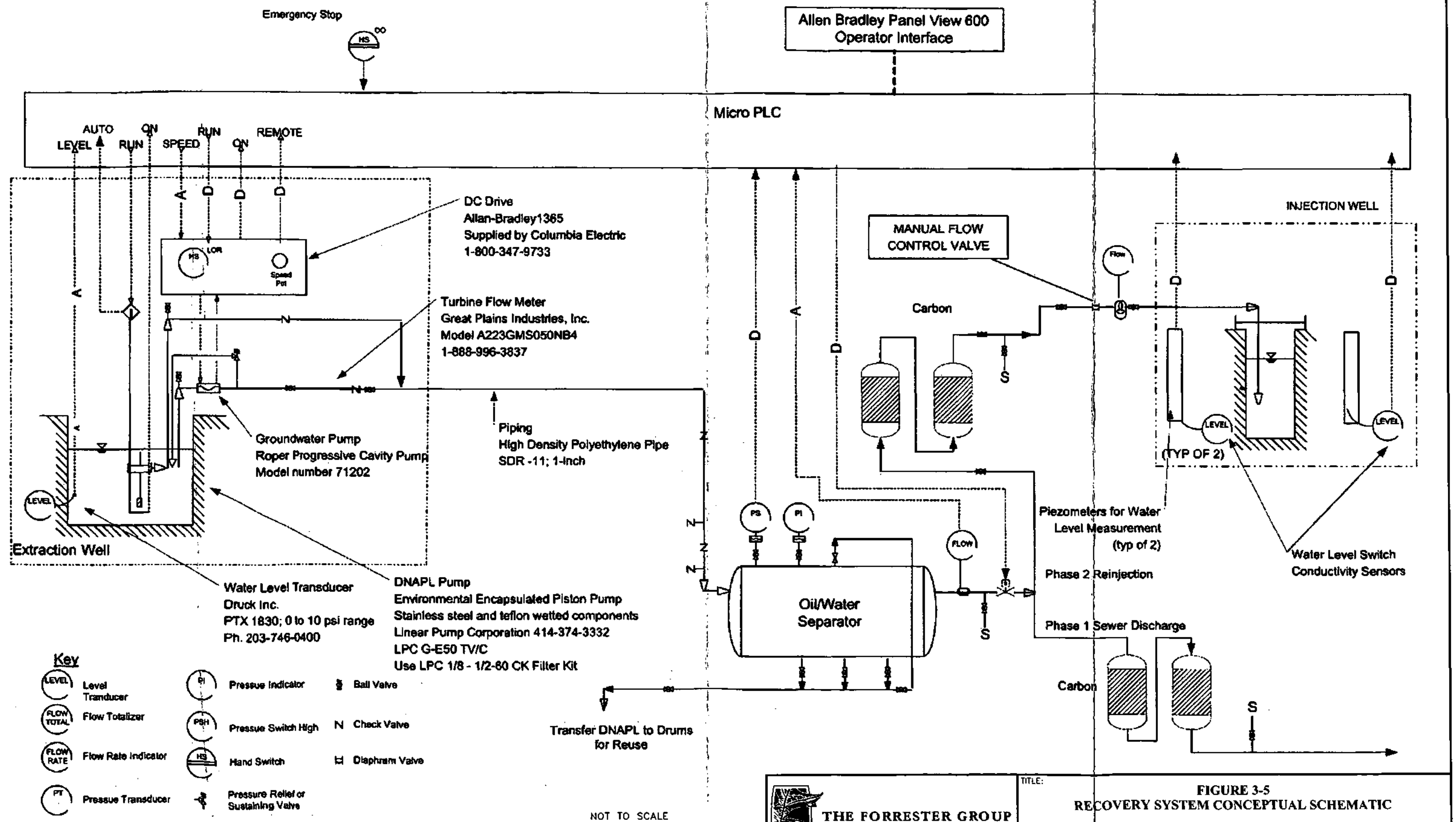
INSIGHTFUL ENVIRONMENTAL SOLUTIONS™

TITLE:

FIGURE 3-4
DNAPL RECOVERY LOCATIONS

UNION PACIFIC RAILROAD FACILITY
OGDEN, UTAH

1330-X1.dwg 2452986.64303291

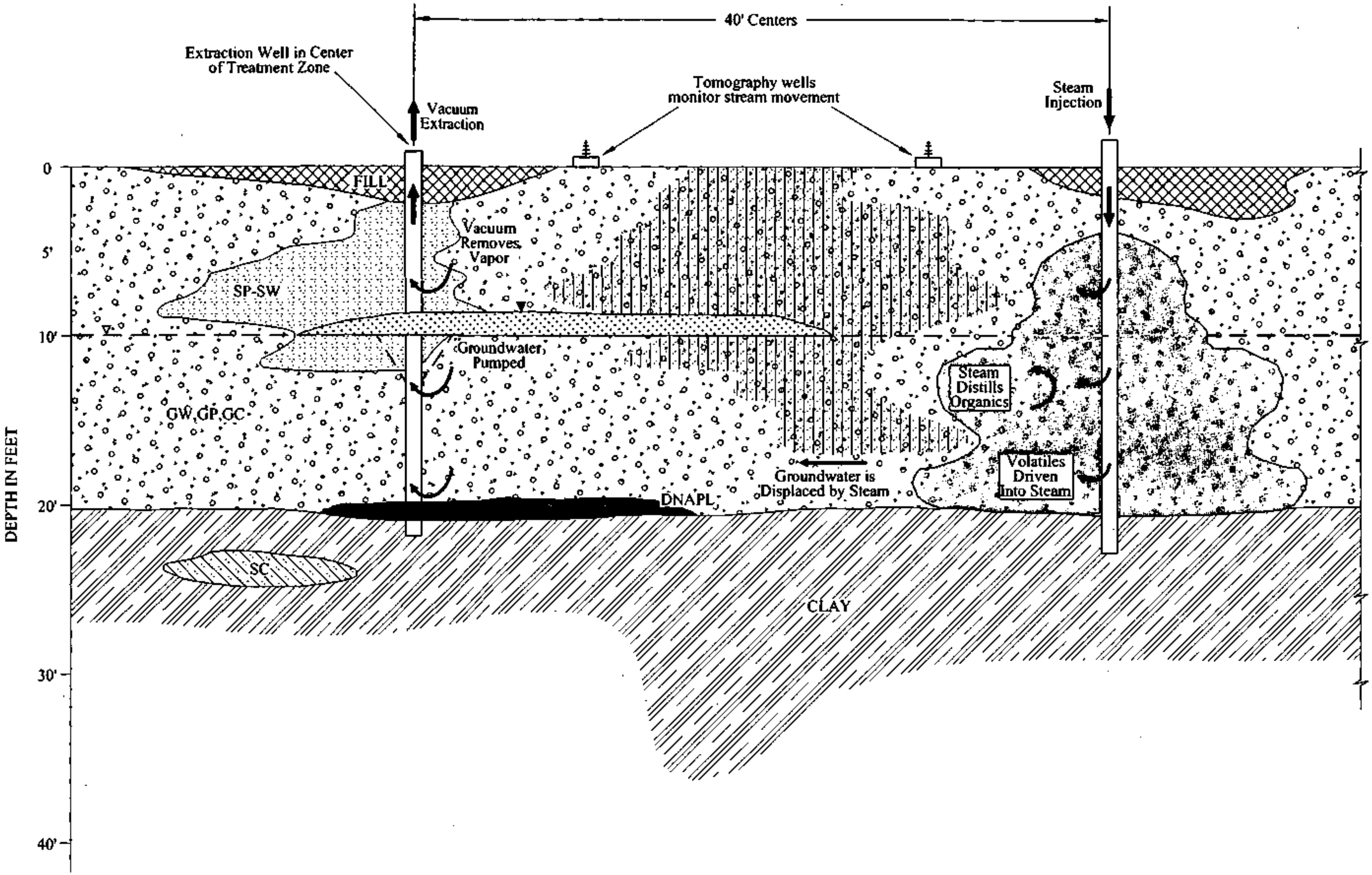


THE FORRESTER GROUP
INSIGHTFUL ENVIRONMENTAL SOLUTIONS™

TITLE:
FIGURE 3-5
RECOVERY SYSTEM CONCEPTUAL SCHEMATIC

UNION PACIFIC RAILROAD FACILITY
OGDEN, UTAH

1330-X6.dwg 2452926.62802505



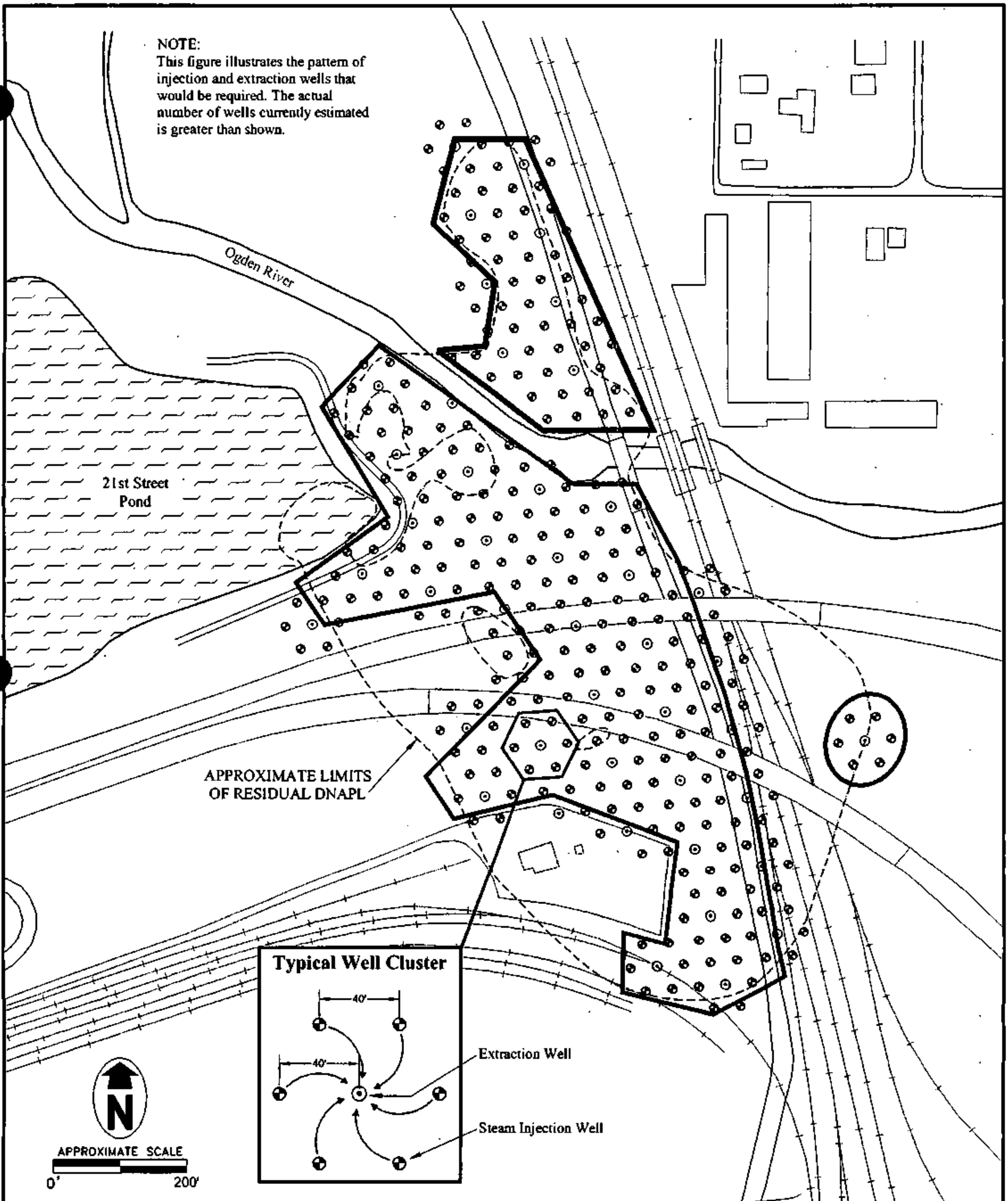
THE FORRESTER GROUP
INSIGHTFUL ENVIRONMENTAL SOLUTIONS™

TITLE:

FIGURE 3-6
DUS SCHEMATIC

UNION PACIFIC RAILROAD FACILITY
OGDEN, UTAH

1330-X2.dwg 2452915.7325219



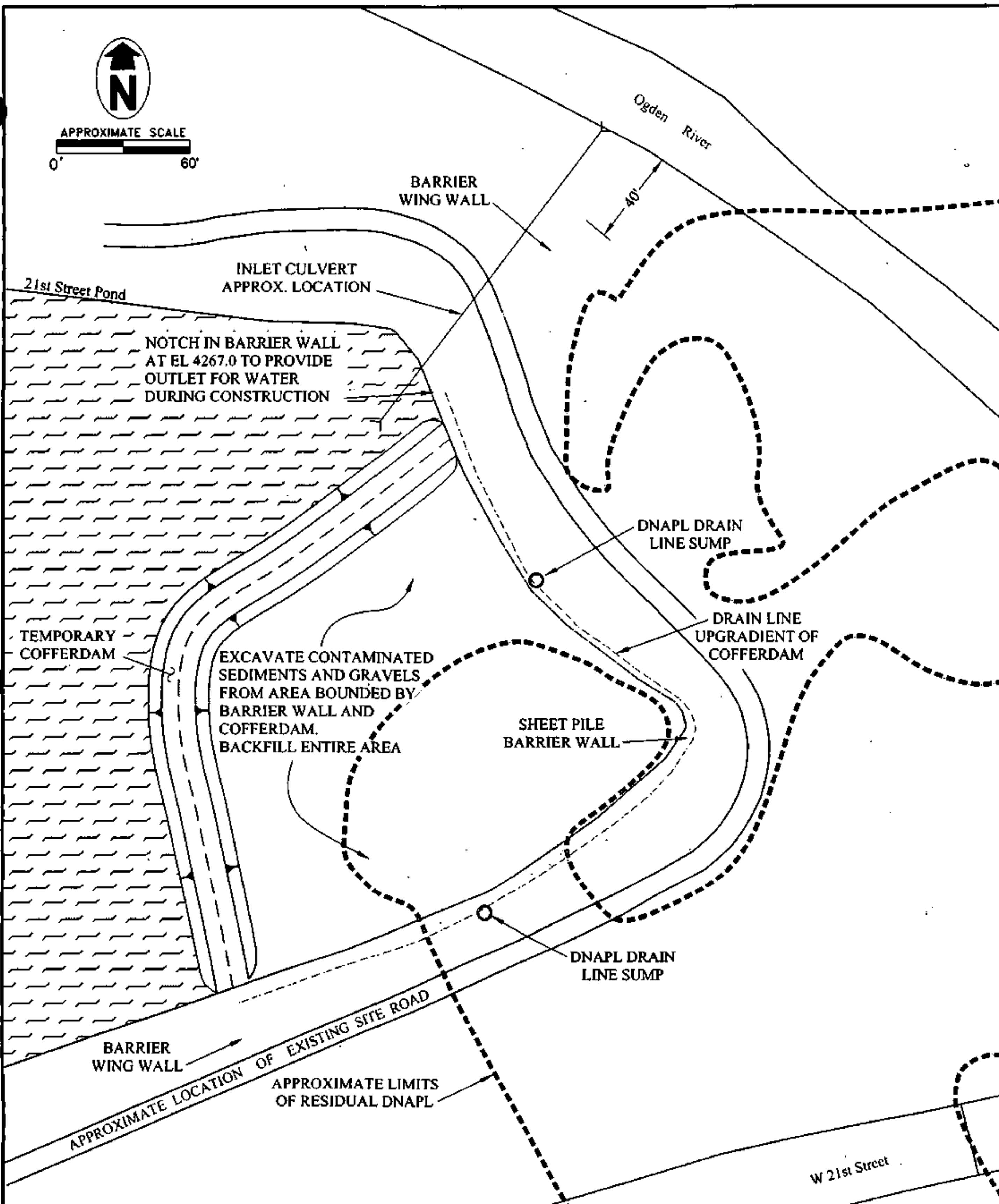
THE FORRESTER GROUP
INSIGHTFUL ENVIRONMENTAL SOLUTIONS™

TITLE:

FIGURE 3-7
DUS/HPO DNAPL TREATMENT LAYOUT

UNION PACIFIC RAILROAD FACILITY
OGDEN, UTAH

1330-X1.dwg 2453272.4751453



THE FORRESTER GROUP
INSIGHTFUL ENVIRONMENTAL SOLUTIONS™

TITLE:

FIGURE 3-8
PLAN OF POND SEDIMENT EXCAVATION AREA
UNION PACIFIC RAILROAD FACILITY
OGDEN, UTAH

1330-X1.dwg 2452986.64303291

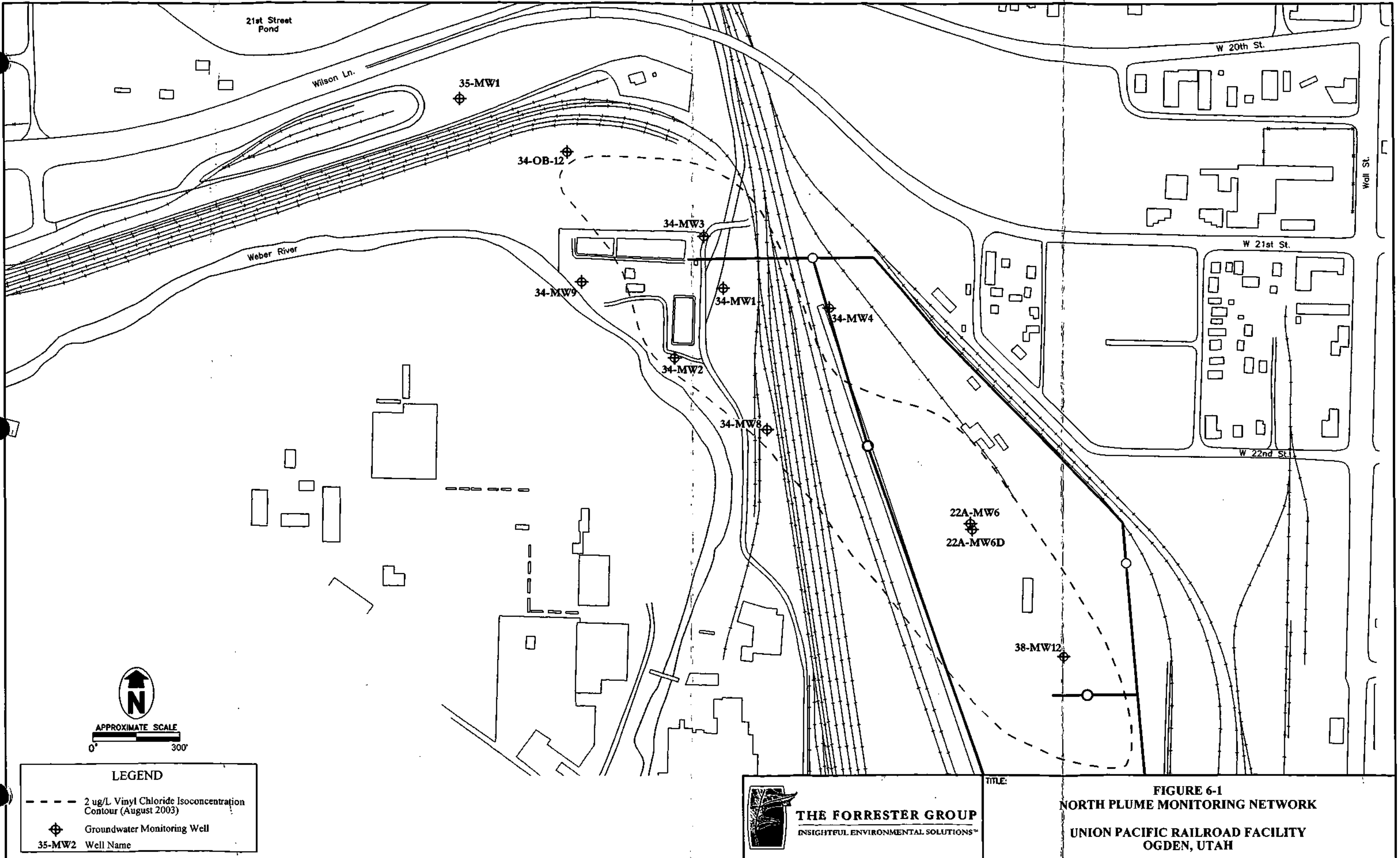
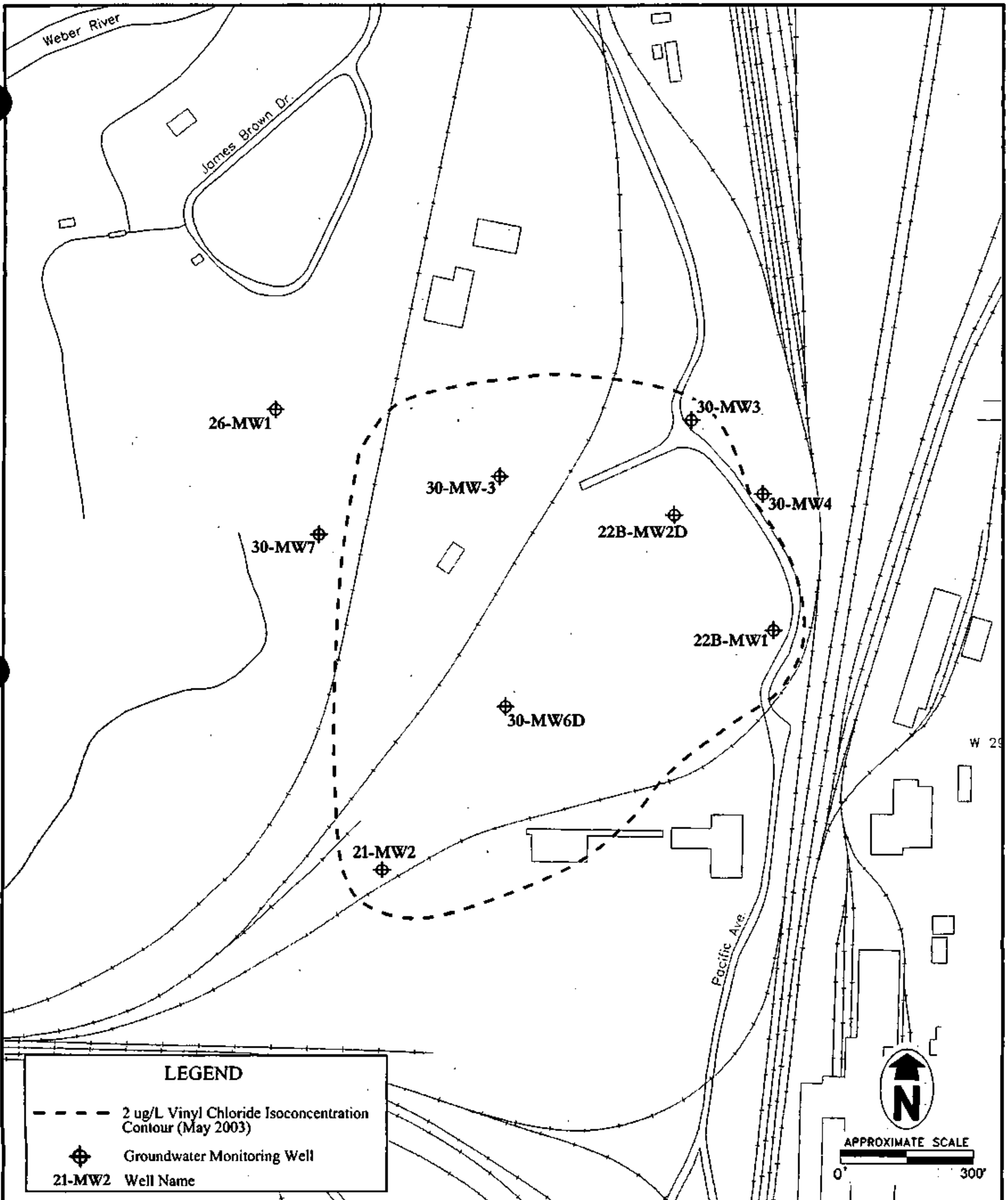


FIGURE 6-1
NORTH PLUME MONITORING NETWORK

UNION PACIFIC RAILROAD FACILITY
OGDEN, UTAH

1330-X1.dwg 2453272.7322285



THE FORRESTER GROUP

INSIGHTFUL ENVIRONMENTAL SOLUTIONS™

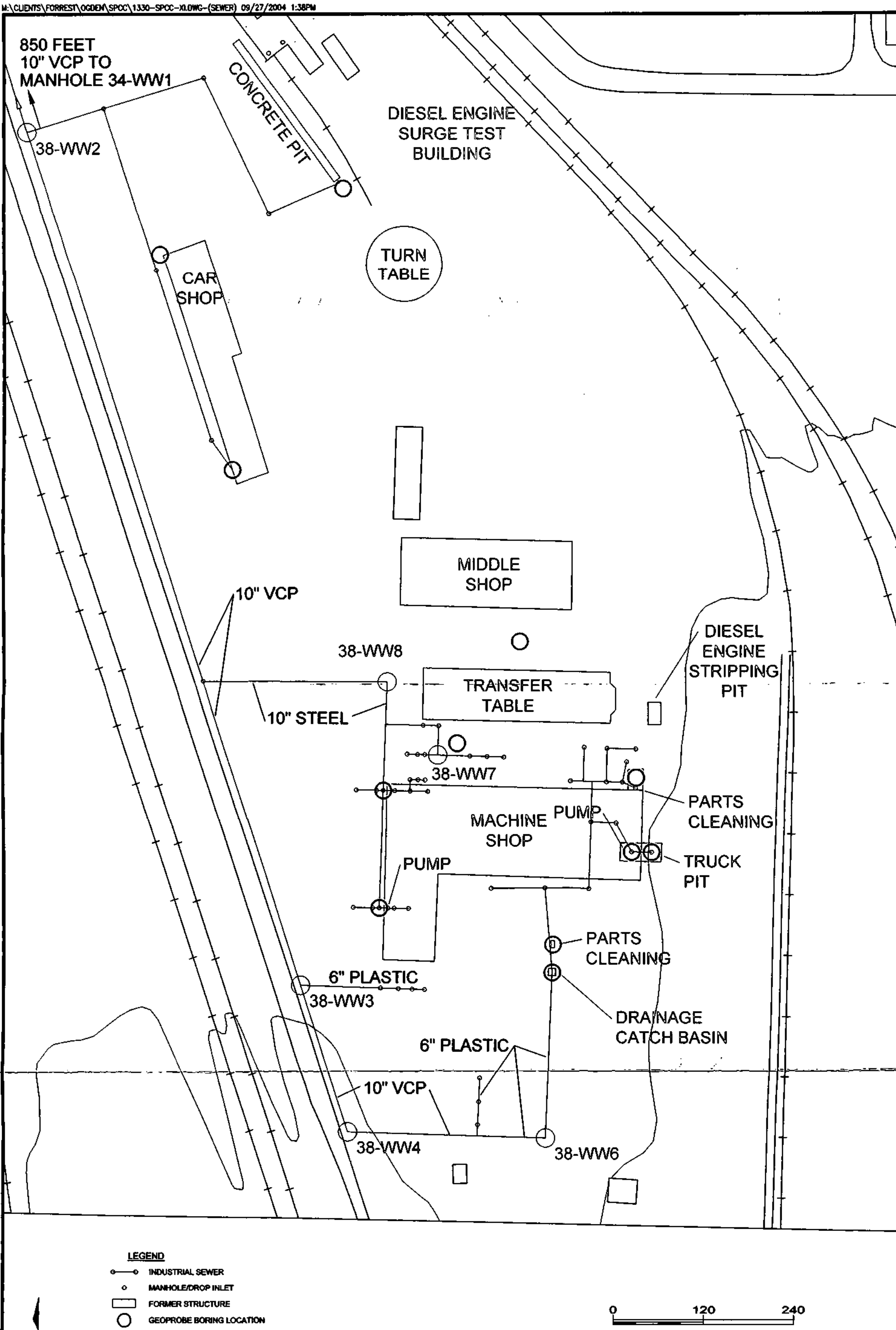
TITLE:

FIGURE 6-2
SOUTH PLUME MONITORING WELL NETWORK

UNION PACIFIC RAILROAD FACILITY
OGDEN, UTAH

1330-X1.dwg 2452934.4751817

M:\CLIENTS\FORREST\OGDEN\SPCC\1330-SPCC-XI.DWG-(SEWER) 09/27/2004 1:38PM



	BY	DATE
DRAWN	RJV	2/5/04
CHECKED		
APPROVED		
APPROVED		
APPROVED		

THE FORRESTER GROUP
INSIGHTFUL ENVIRONMENTAL SOLUTIONS™

UNION PACIFIC RAILROAD-OGDEN, UTAH

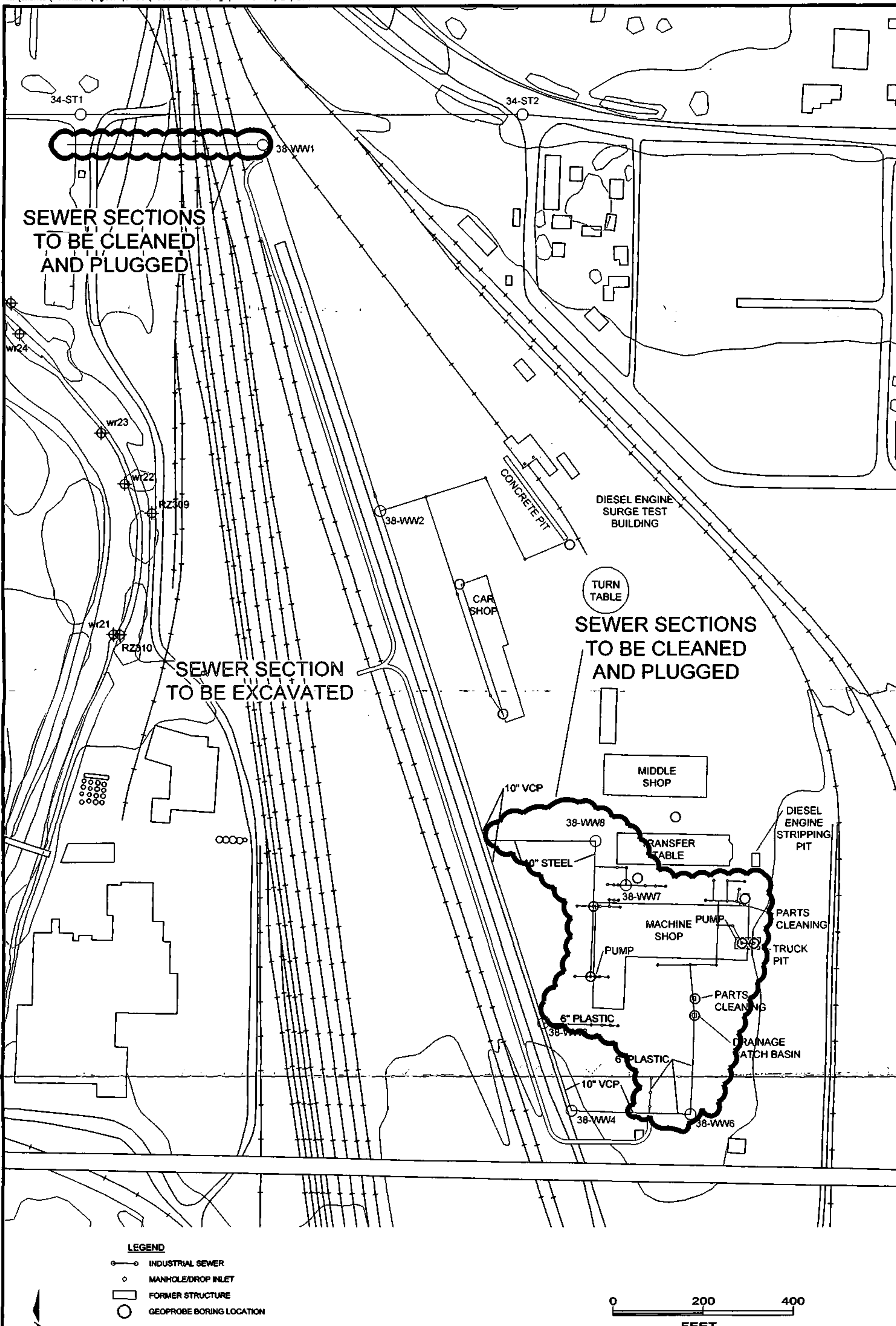
FIGURE 6-3a

INDUSTRIAL SEWER DIAGRAM

SCALE: 1"=120'

DWG. NO.: 1330-SPCC-XI.dwg

M:\clients\FORREST\Ogden\SPCC\1330-SEWER.dwg plotted: 09/27/2004



BY	DATE
DRAWN RJV	2/5/04
CHECKED	
APPROVED	
APPROVED	
APPROVED	

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INSIGHTFUL ENVIRONMENTAL SOLUTIONS™

UNION PACIFIC RAILROAD-OGDEN, UTAH

FIGURE 6-3b

SEWER SECTIONS TO BE CLEANED & CAPPED

SCALE: 1"=200

DWG. NO.: 1330-SEWER.dwg

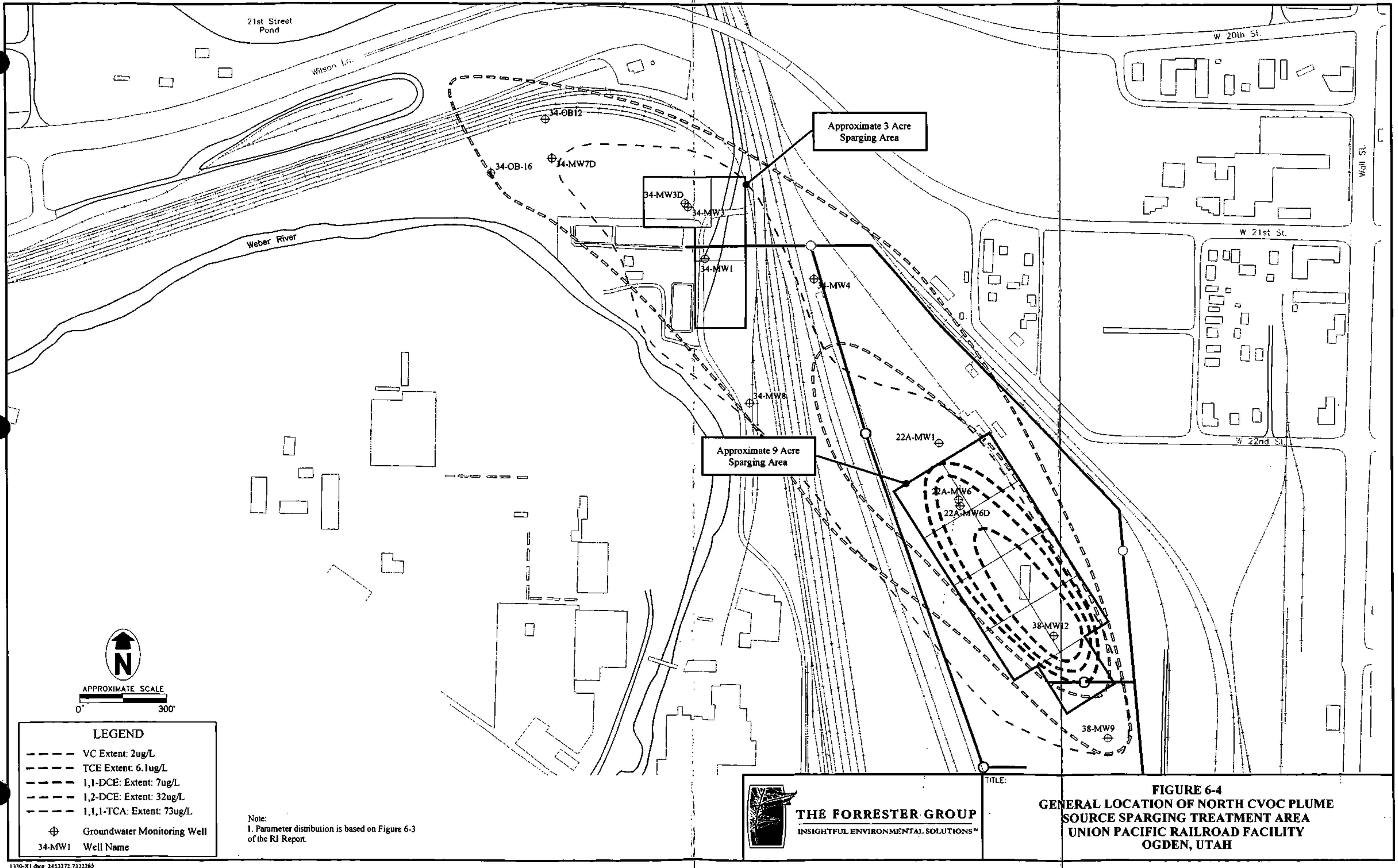
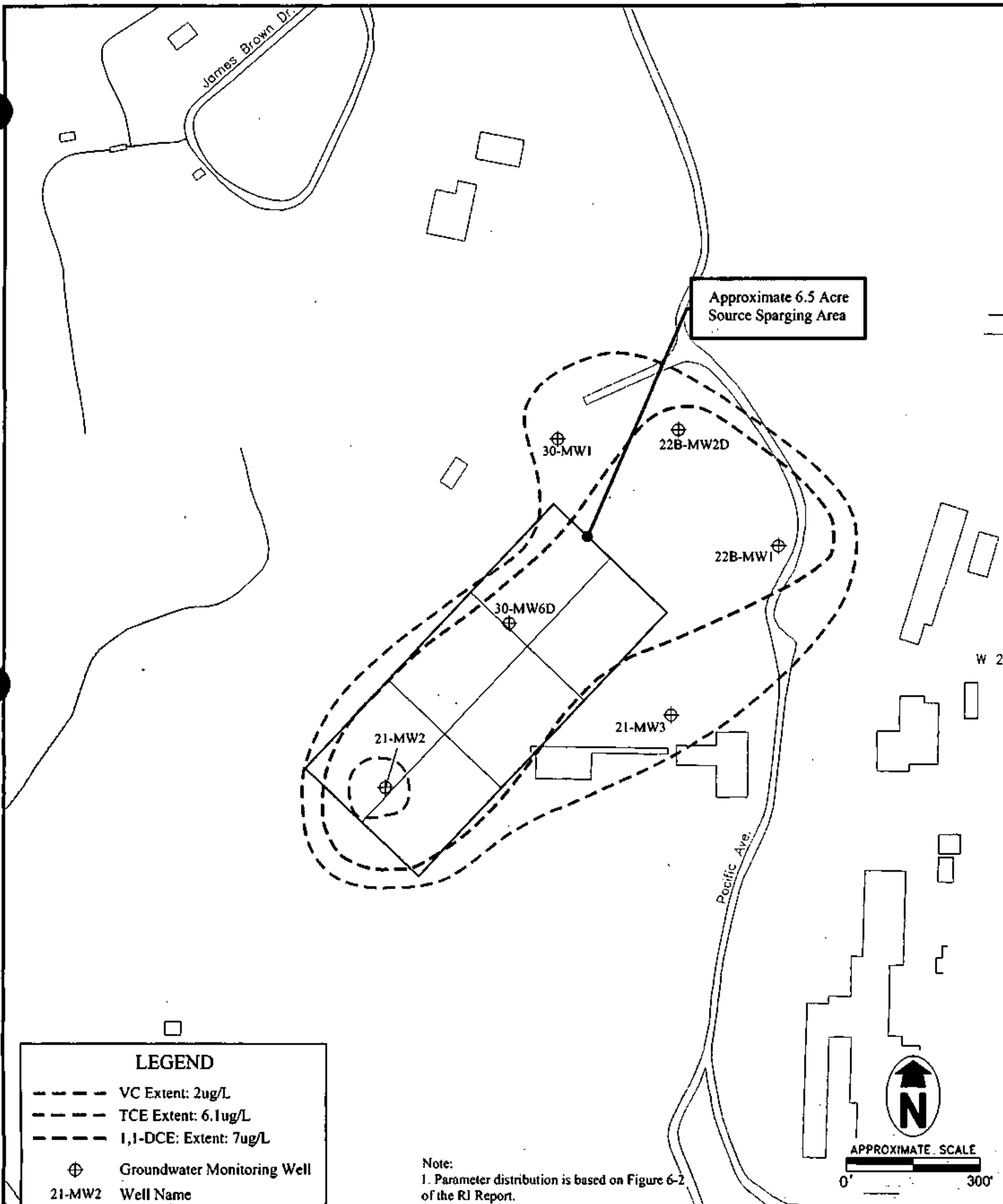


FIGURE 6-4
GENERAL LOCATION OF NORTH CVOC PLUME SOURCE SPARGING TREATMENT AREA
UNION PACIFIC RAILROAD FACILITY
OGDEN, UTAH



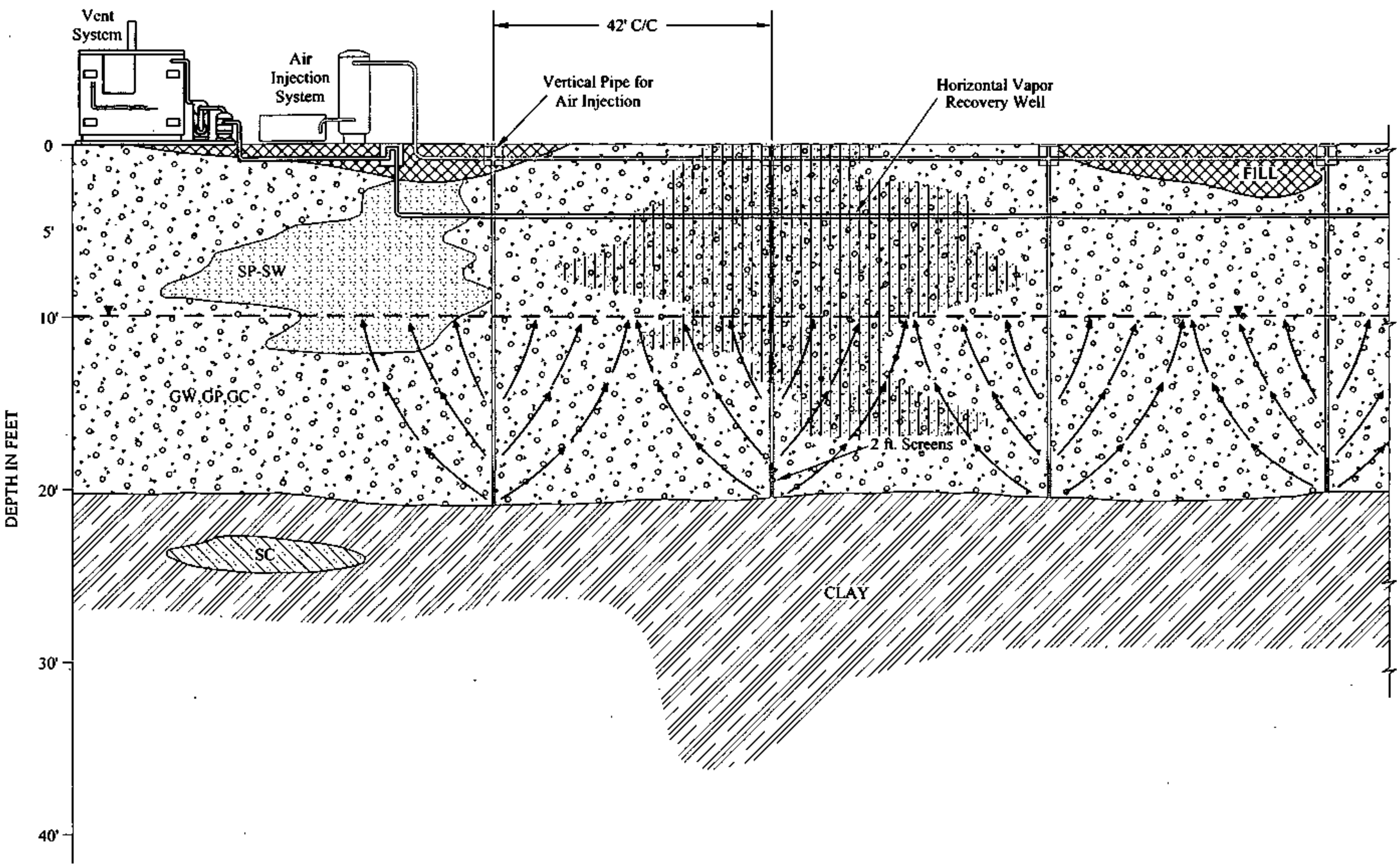
THE FORRESTER GROUP

INSIGHTFUL ENVIRONMENTAL SOLUTIONS™

TITLE:

FIGURE 6-5
GENERAL LOCATION OF SOUTH CVOC PLUME SOURCE SPARGING TREATMENT AREA
UNION PACIFIC RAILROAD FACILITY
OGDEN, UTAH

1330-X1.dwg 2452915.74931086



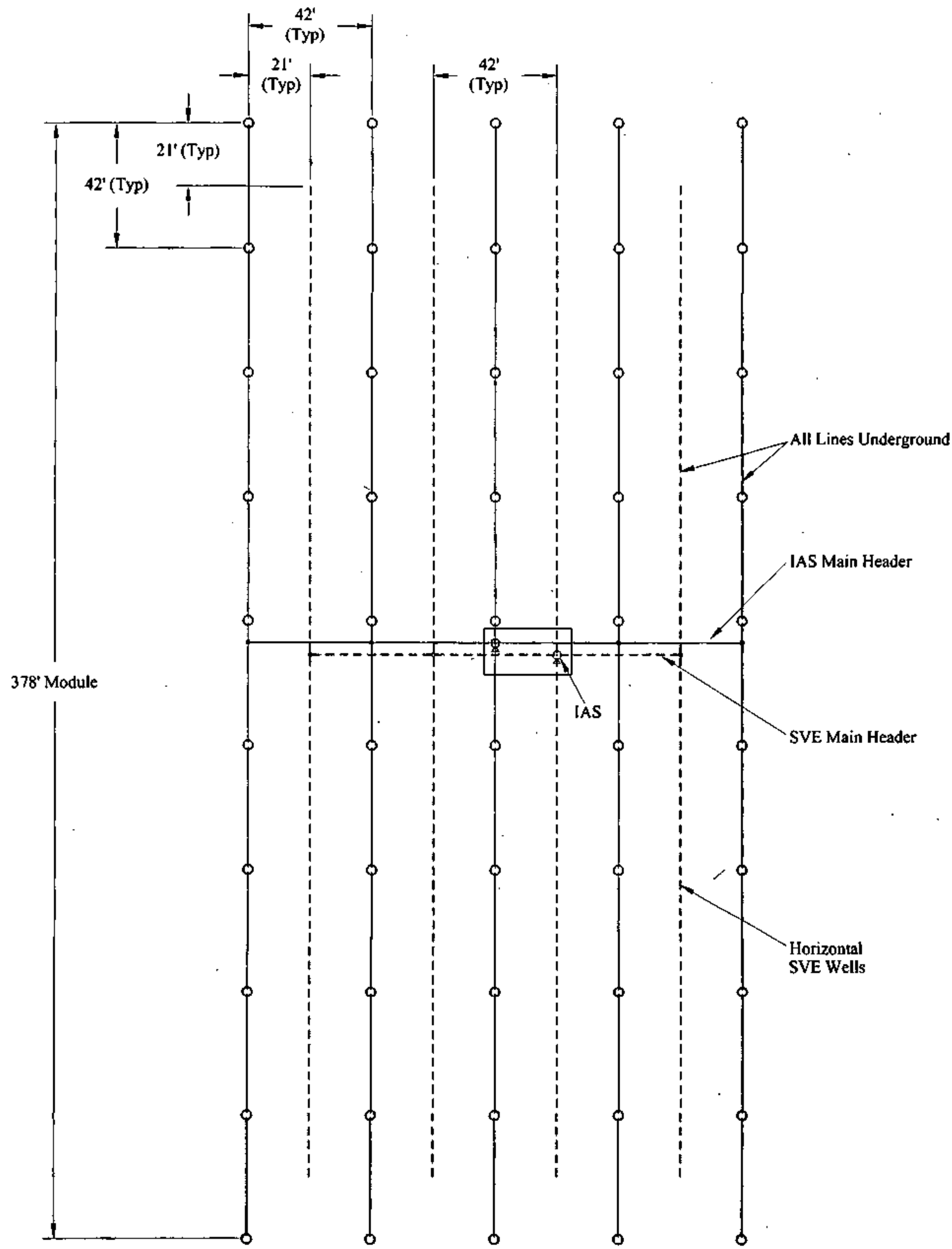
THE FORRESTER GROUP

INSIGHTFUL ENVIRONMENTAL SOLUTIONS™

TITLE:

FIGURE 6-6
CONCEPTUAL CROSS-SECTION OF NORTH PLUME SPARGING UNION PACIFIC RAILROAD FACILITY OGDEN, UTAH

1330-X2.dwg 2452919 72117446



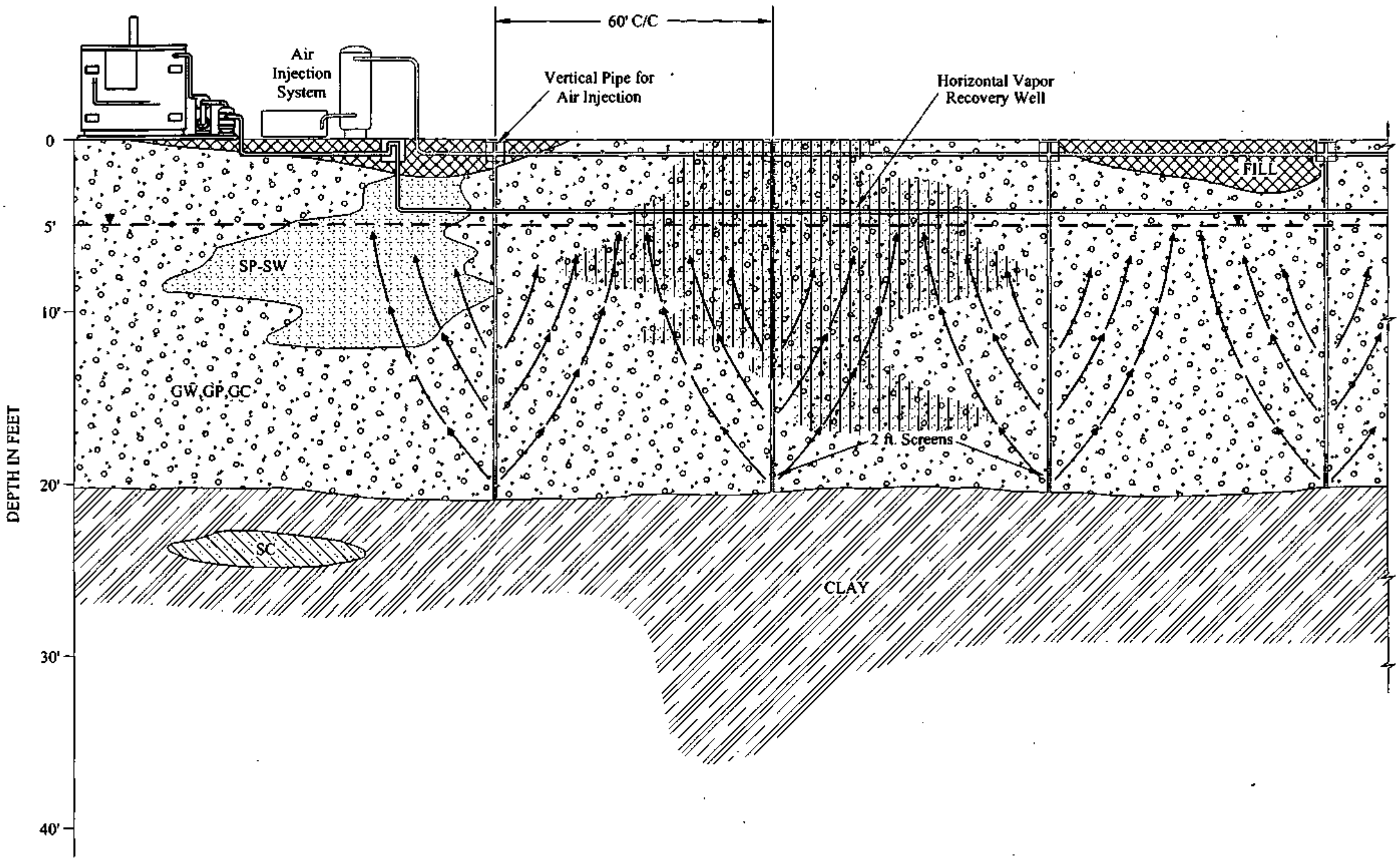
THE FORRESTER GROUP
INSIGHTFUL ENVIRONMENTAL SOLUTIONS™

TITLE:

FIGURE 6-7
NORTH PLUME SPARGING MODULE LAYOUT

UNION PACIFIC RAILROAD FACILITY
OGDEN, UTAH

1330-X4.dwg 2452914.75320289

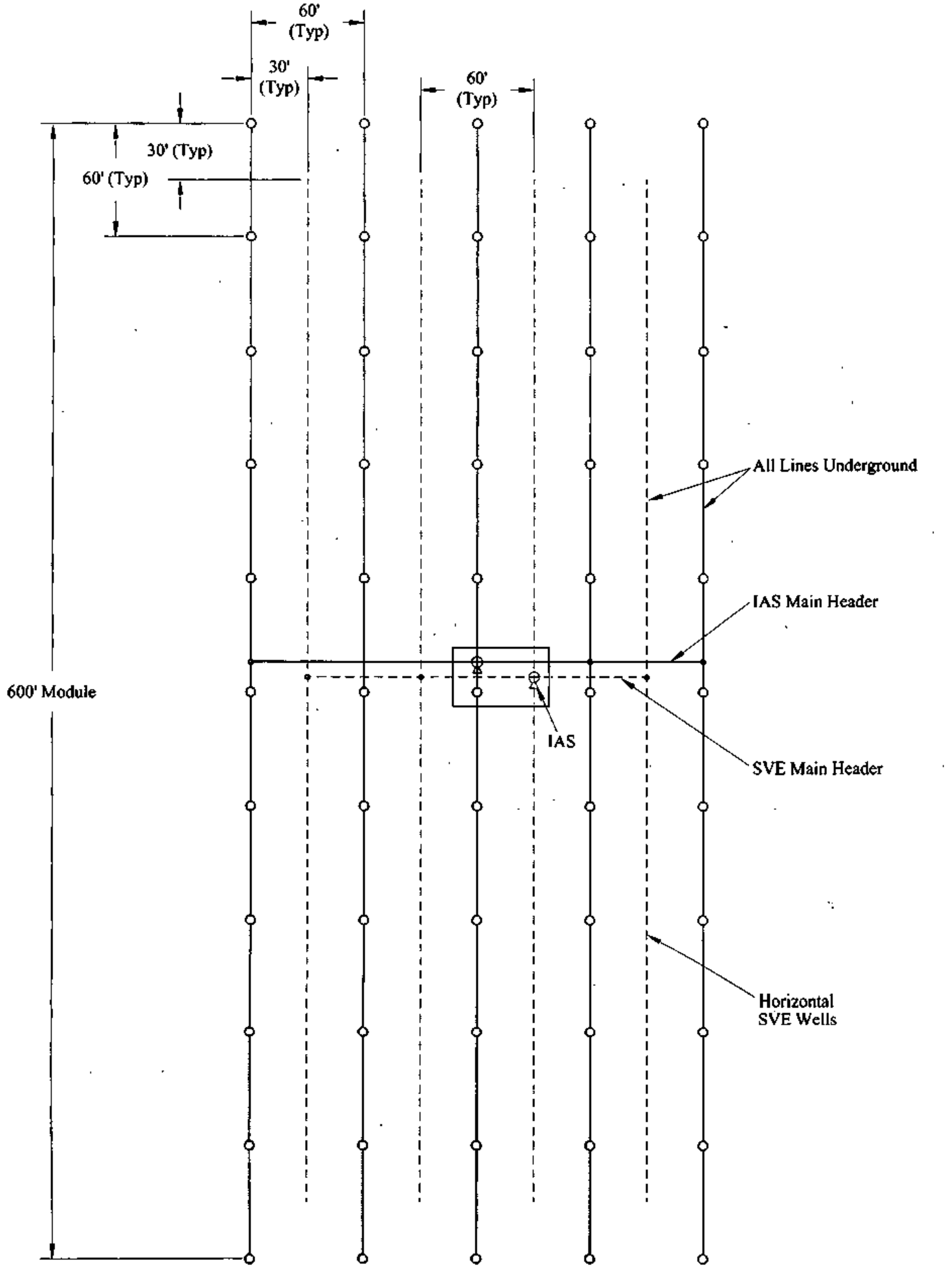


THE FORRESTER GROUP
INSIGHTFUL ENVIRONMENTAL SOLUTIONS™

TITLE:

FIGURE 6-8
CONCEPTUAL CROSS-SECTION OF SOUTH PLUME SPARGING
UNION PACIFIC RAILROAD FACILITY
OGDEN, UTAH

1330-X2.dwg 2452919.71857454



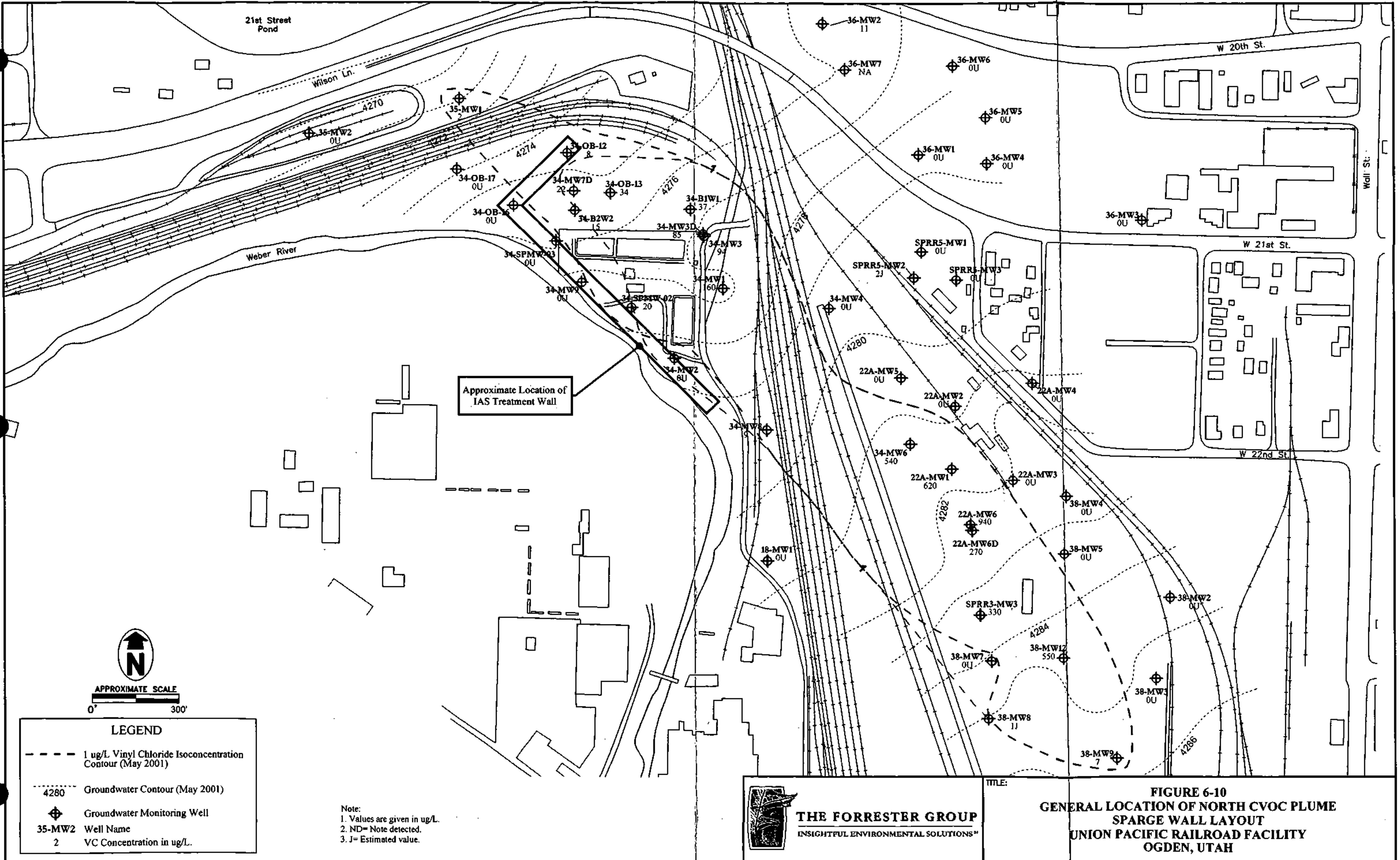
THE FORRESTER GROUP
INSIGHTFUL ENVIRONMENTAL SOLUTIONS™

TITLE:

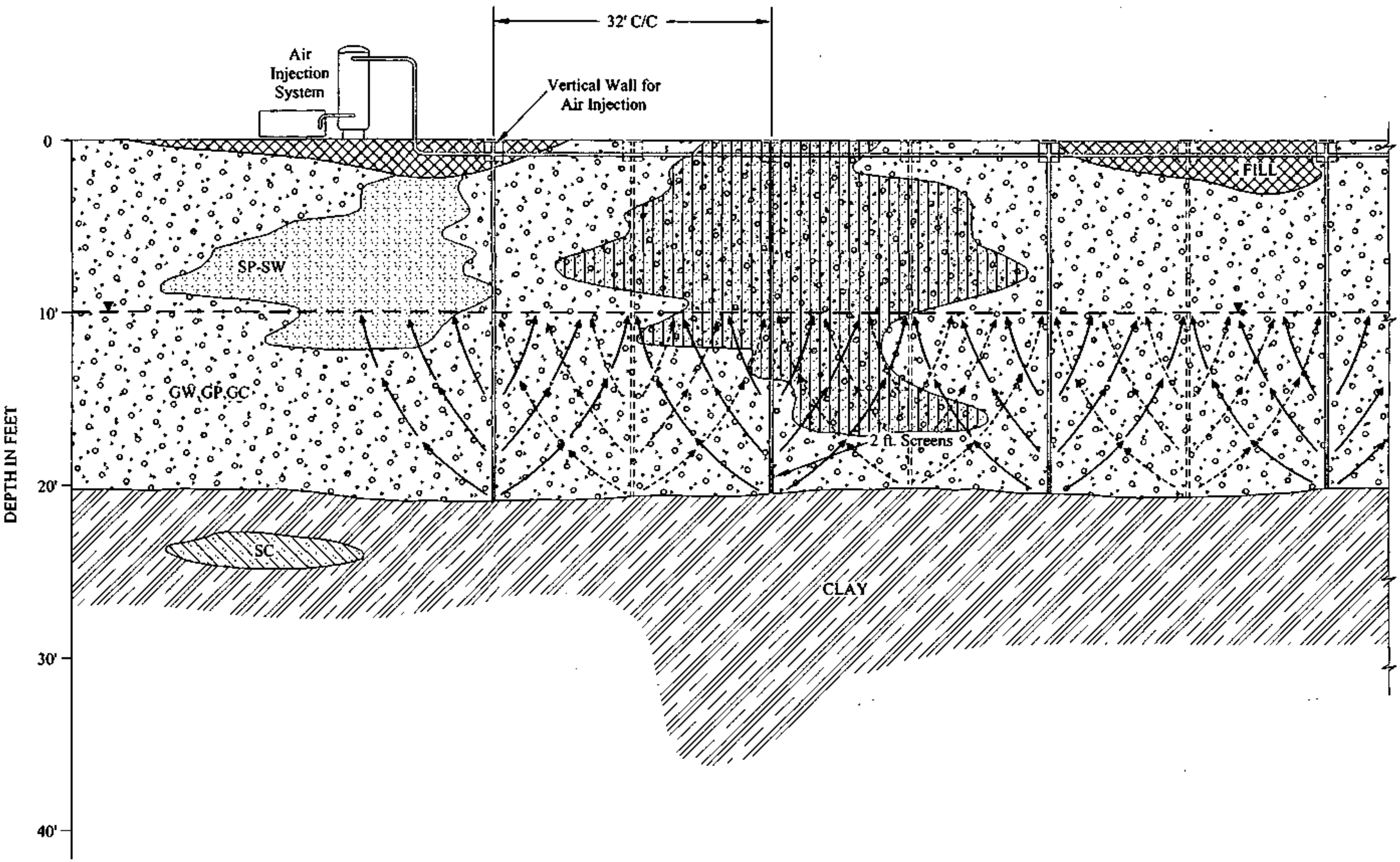
FIGURE 6-9
SOUTH PLUME SPARGING MODULE LAYOUT

UNION PACIFIC RAILROAD FACILITY
OGDEN, UTAH

1330-X4.dwg 2452915.75355927



21st Street Pond
Wilson Ln.
W 20th St.
W 21st St.
W 22nd St.
Wall St.
Weber River
4270
4272
4274
4276
4278
4280
4282
4284
4286
35-MW1 2
35-MW2 0U
34-OB-12 8
34-OB-17 0U
34-OB-13 34
34-MW7D 22
34-OB-15 0U
34-B2W2 15
34-B1W1 37
34-MW3D 85
34-MW3 94
34-SPMW-03 0U
34-MW1 160
34-MW9 0U
34-SPMW-02 20
34-MW4 0U
34-MW2 0U
34-MW8
18-MW1 0U
36-MW2 11
36-MW7 NA
36-MW6 0U
36-MW5 0U
36-MW1 0U
36-MW4 0U
36-MW3 0U
SPRR5-MW1 0U
SPRR5-MW2 2J
SPRR5-MW3 0U
22A-MW5 0U
22A-MW2 0U
22A-MW4 0U
34-MW6 540
22A-MW1 620
22A-MW3 0U
38-MW4 0U
22A-MW6 940
22A-MW6D 270
38-MW5 0U
38-MW2 0U
SPRR3-MW3 330
38-MW12 550
38-MW7 0U
38-MW3 0U
38-MW8 1J
38-MW9 7
Approximate Location of IAS Treatment Wall
N
APPROXIMATE SCALE
0' 300'
LEGEND
1 ug/L Vinyl Chloride Isoconcentration Contour (May 2001)
4280 Groundwater Contour (May 2001)
Groundwater Monitoring Well
35-MW2 Well Name
2 VC Concentration in ug/L.
Note:
1. Values are given in ug/L.
2. ND= Note detected.
3. J= Estimated value.
THE FORRESTER GROUP
INSIGHTFUL ENVIRONMENTAL SOLUTIONS
TITLE:
FIGURE 6-10
GENERAL LOCATION OF NORTH CVOC PLUME
SPARGE WALL LAYOUT
UNION PACIFIC RAILROAD FACILITY
OGDEN, UTAH

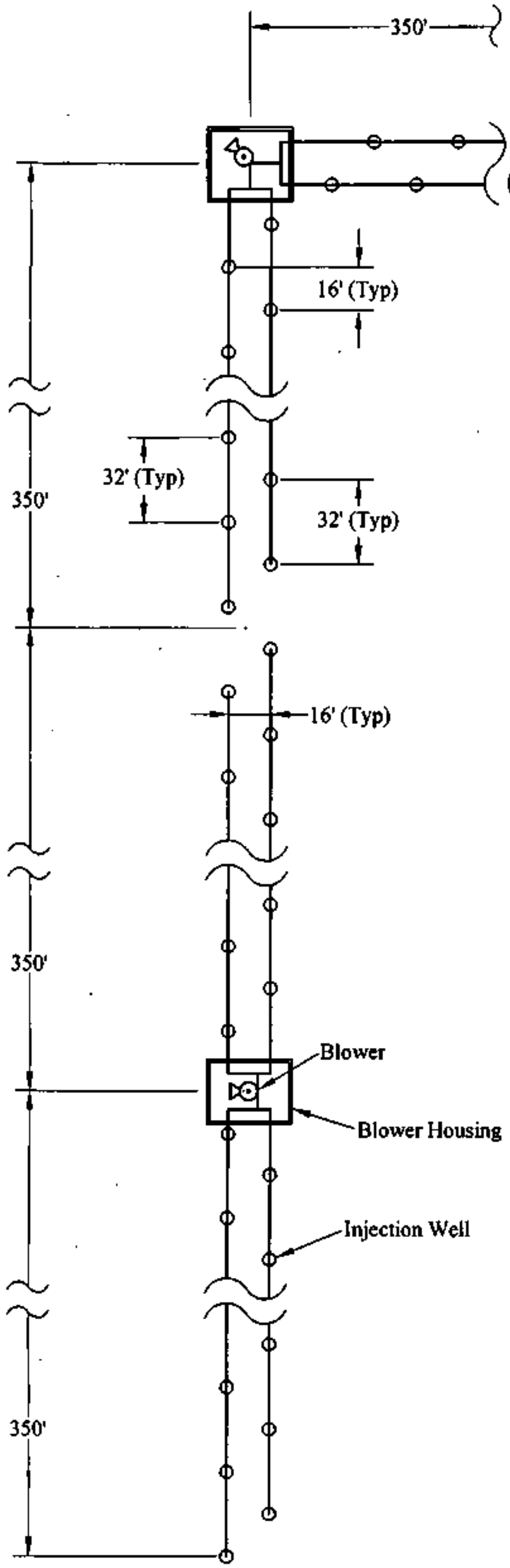


THE FORRESTER GROUP
INSIGHTFUL ENVIRONMENTAL SOLUTIONS℠

TITLE:

FIGURE 6-11
CONCEPTUAL CROSS-SECTION OF NORTH PLUME SPARGING WALL
UNION PACIFIC RAILROAD FACILITY
OGDEN, UTAH

1330-X2.dwg 2452920.37911082

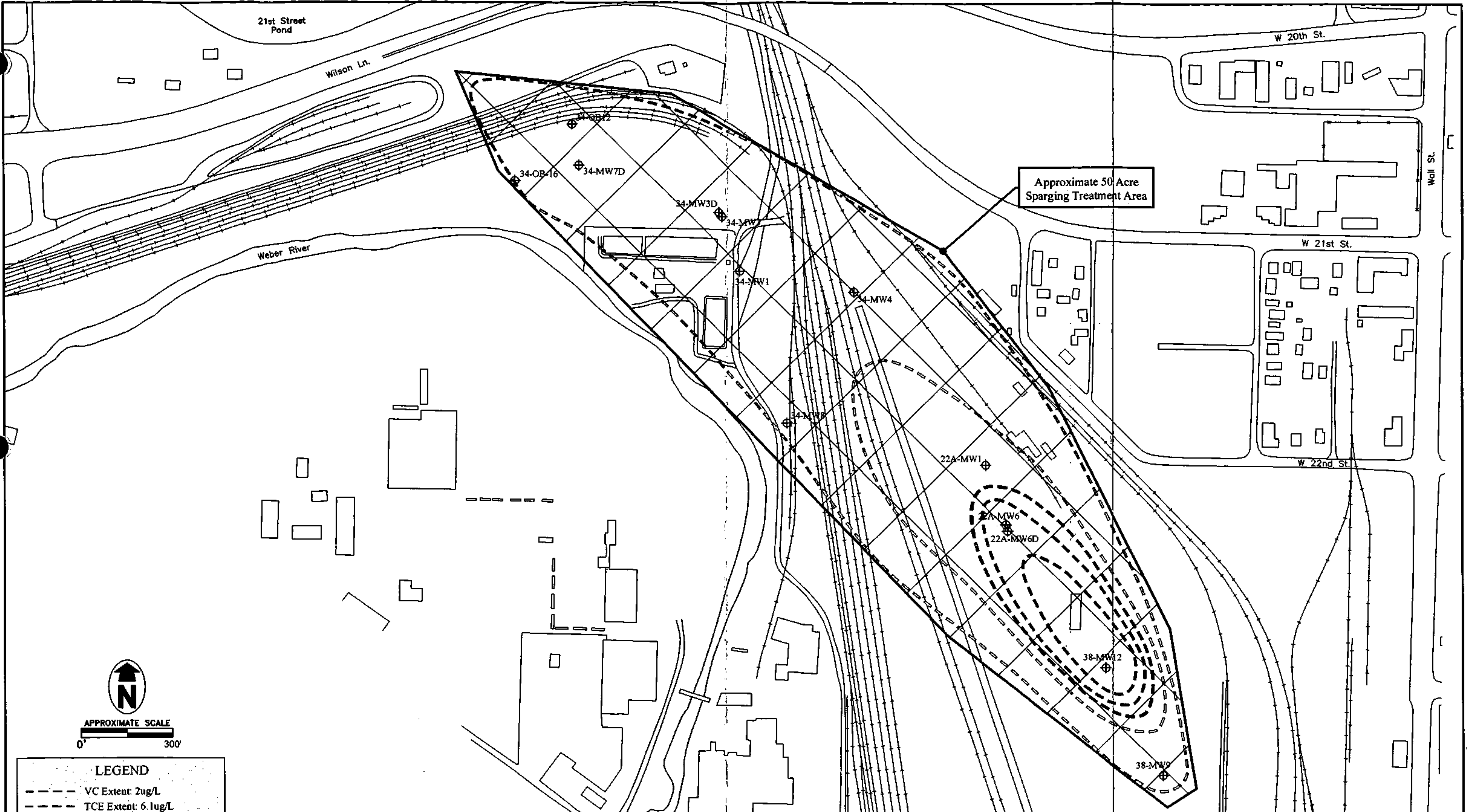


THE FORRESTER GROUP
INSIGHTFUL ENVIRONMENTAL SOLUTIONS™

TITLE:

FIGURE 6-12
PLAN VIEW LAYOUT OF
NORTH PLUME SPARGING WALL
UNION PACIFIC RAILROAD FACILITY
OGDEN, UTAH

1330-X4.dwg 2452915.75419945



LEGEND

- VC Extent: 2ug/L
- TCE Extent: 6.1ug/L
- 1,1-DCE: Extent: 7ug/L
- 1,2-DCE: Extent: 32ug/L
- 1,1,1-TCA: Extent: 73ug/L
- ⊕ Groundwater Monitoring Well
- 21-MW2 Well Name

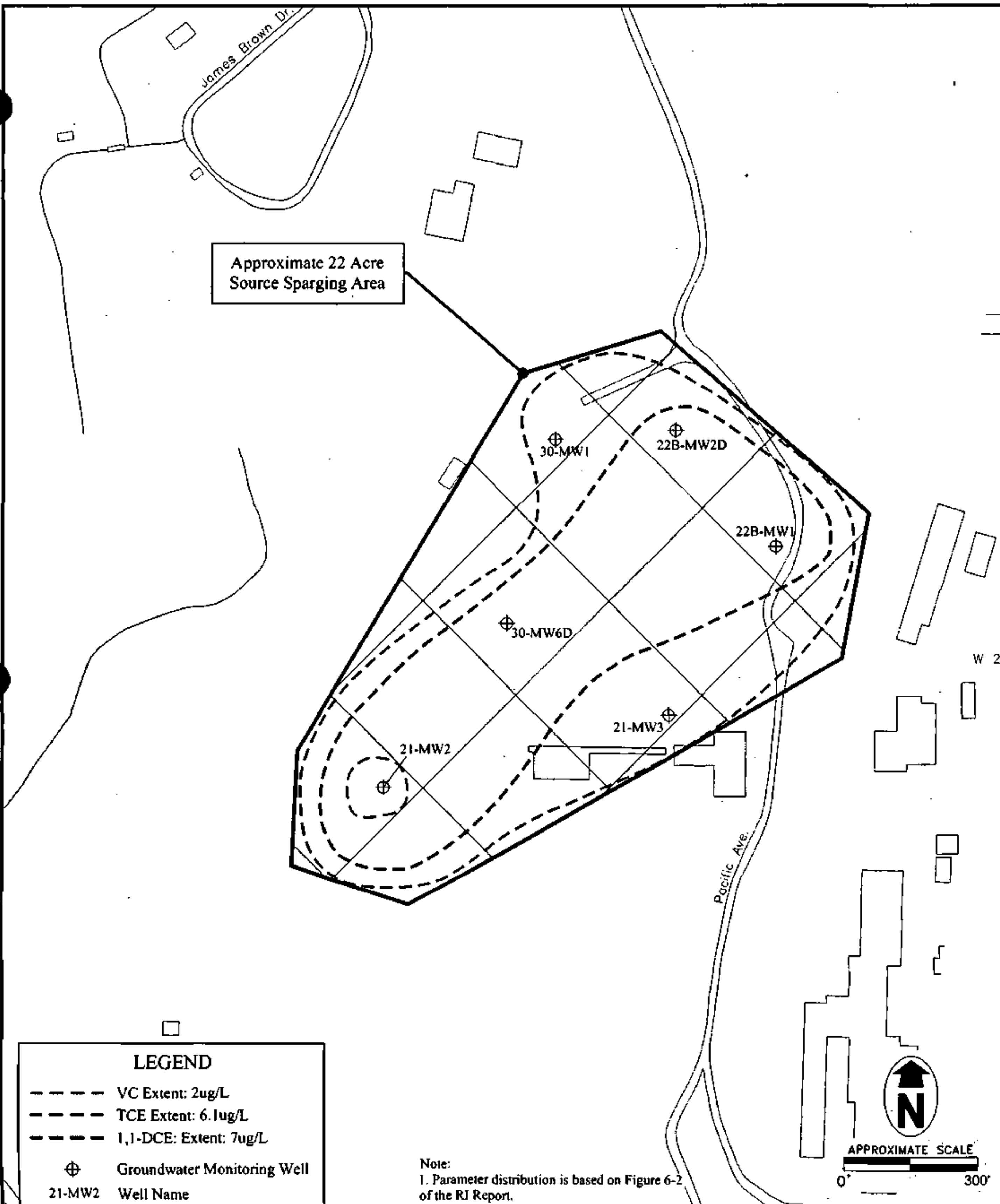
Note:
1. Parameter distribution is based on Figure 6-3 of the RI Report.

THE FORRESTER GROUP
INSIGHTFUL ENVIRONMENTAL SOLUTIONS™

TITLE:

FIGURE 6-13
GENERAL LOCATION OF NORTH CVOC PLUME
50 ACRE SPARGING TREATMENT AREA
UNION PACIFIC RAILROAD FACILITY
OGDEN, UTAH

1330-X1.dwg 2453272.7322285



THE FORRESTER GROUP

INSIGHTFUL ENVIRONMENTAL SOLUTIONS™

TITLE:

FIGURE 6-14
GENERAL LOCATION OF SOUTH CVOC PLUME
24 ACRE SPARGING TREATMENT AREA
UNION PACIFIC RAILROAD FACILITY
OGDEN, UTAH

1330-X1.dwg 2452915.74197257

TABLES

Table 3-1
UPRR Ogden Rail Yard Feasablity Study
AOI-33 Monitoring Wells

Monitoring Well	DNAPL/Water Gauging	Groundwater Analytical Methods
33-MW1	X	SVOCs (PAHs) SW846 Method 8310; VOCs SW846 Method 8260B (All wells)
33-MW1FP	X	
33-MP2	X	
33-MW2	X	
33-MW2FP	X	
33-MP3	X	
33-MW3	X	
33-MW4	X	
33-MW4FP	X	
33-MW5	X	
33-MW5FP	X	
33-MW6	X	
33-MW6FP	X	
33-MW8	X	
33-MW10FP	X	
33-MW12FP	X	

Table 4-1
Detailed Analysis of Northern Area Alternatives
UPRR Ogden Rail Yard Feasibility Study

Evaluation Criteria Description	Alternative 1 No Action	Alternative 2 Interim Actions Implemented to Date with Monitoring	Alternative 3 Pond Sediment Remedy with DNAPL Recovery and Institutional Controls	Alternative 4 Pond Sediment Remedy with Intensive DNAPL Zone Treatment and Institutional Controls	Alternative 5 Pond Sediment Removal with Intensive DNAPL Zone Treatment and Institutional Controls
1. Overall Protection					
-Protect human and ecological receptors from exposure to DNAPL contaminated sediments at the 21st Street Pond.	No. Current conditions do not prevent present or future exposure to ecological receptors. Interim actions and institutional controls prevent human exposure.	No. Current conditions do not prevent present or future exposure to ecological receptors. Interim actions and institutional controls prevent human exposure.	Yes. Once containment is achieved, future exposure is prevented.	Yes. Once pond sediments are removed, future exposure is prevented. However, it is difficult to ensure in wet excavation that all DNAPL-impacted sediments are removed.	Yes. Once pond sediments are removed, future exposure is prevented. However, it is difficult to ensure in wet excavation that all DNAPL-impacted sediments are removed.
-Prevent unacceptable exposure risk to current and future human populations presented by direct contact, inhalation, or ingestion of contaminated groundwater.	No. Unacceptable exposure risks to current human populations do not exist and future exposure is unlikely. Without continued monitoring, achievement of this objective cannot be demonstrated.	Yes. Unacceptable exposure risks to current human populations do not exist and future exposure is unlikely. With continued monitoring, this objective can be demonstrated.	Yes. Unacceptable exposure risks to current human populations do not exist and future exposure is unlikely. Enforceable institutional control prevents future exposure to impacted groundwater zones. With continued monitoring, this objective can be demonstrated.	Yes. Unacceptable exposure risks to current human populations do not exist and future exposure is unlikely. Enforceable institutional control prevents future exposure to impacted groundwater zones. With continued monitoring, this objective can be demonstrated.	Yes. Unacceptable exposure risks to current human populations do not exist and future exposure is unlikely. Enforceable institutional control prevents future exposure to impacted groundwater zones. With continued monitoring, this objective can be demonstrated.
-Prevent potential future groundwater plume migration as necessary to protect current and potential beneficial uses of groundwater in the vicinity of the site, and to be protective of surface waters and their designated uses.	No. Monitoring data and calculations indicate the plume is not migrating. However, without monitoring data, this objective cannot be evaluated.	Yes. Monitoring data and calculations indicate the plume is not migrating. This objective can be evaluated with monitoring data.	Yes. Monitoring data and calculations indicate the plume is not migrating. This objective can be evaluated with monitoring data.	Yes. Monitoring data and calculations indicate the plume is not migrating. Attainment of this objective can be evaluated with monitoring data. Some uncertainty exists regarding potential migration during remedial action (see "sort-term effectivenss" criterion).	Yes. Monitoring data and calculations indicate the plume is not migrating. This objective can be evaluated with monitoring data.
-Restore the groundwater to beneficial uses (as technically practicable).	- No. Without monitoring data, attainment of this objective cannot be evaluated. - Complete restoration of zones impacted by a DNAPL to drinking water criteria (e.g., MCLs) has never been demonstrated.	No. Complete restoration of zones impacted by a DNAPL to drinking water criteria (e.g., MCLs) has never been demonstrated.	No. Complete restoration of zones impacted by a DNAPL to drinking water criteria (e.g., MCLs) has never been demonstrated.	No. Complete restoration of zones impacted by a DNAPL to drinking water criteria (e.g., MCLs) has never been demonstrated.	No. Complete restoration of zones impacted by a DNAPL to drinking water criteria (e.g., MCLs) has never been demonstrated.
-Treat, contain, or remove DNAPL to prevent or minimize further spread of the DNAPL.	No. DNAPL is not treated, contained, or removed.	No. DNAPL is not treated, contained, or removed.	Yes. Continuous phase DNAPL is depleted and residual DNAPL is contained.	Yes. Both continuous phase and residual DNAPL is partially removed.	Yes. Both continuous phase and residual DNAPL is partially removed.
2. Compliance with ARARs					
-Action specific ARARs	None apply.	Will be designed to meet action specific ARARs.	Will be designed to meet action specific ARARs.	Will be designed to meet action specific ARARs.	Will be designed to meet action specific ARARs.
-Chemical specific ARARs	Although ACLs may already be met, this cannot be demonstrated without monitoring.	ACLs will be met.	ACLs will be met.	ACLs will be met.	ACLs will be met.
-Location specific ARARs	Will meet all location specific ARARs.	Will meet all location specific ARARs.	Will meet all location specific ARARs.	Will meet all location specific ARARs.	Will meet all location specific ARARs.
3. Long-Term Effectiveness and Permanence					
-Magnitude of residual risk	Reduction in residual risk cannot be verified without monitoring.	Groundwater beneath the site will not achieve drinking water quality. Ecological risk to sediments remains unchanged.	Groundwater beneath the site will not achieve drinking water quality. Impacted sediments remain in place, but risk is mitigated by breaking the exposure pathway.	Groundwater beneath the site will not achieve drinking water quality. Risk of impacted sediments is reduced to acceptable levels by excavation and removal.	Groundwater beneath the site will not achieve drinking water quality. Risk of impacted sediments is reduced to acceptable levels by excavation and removal.
-Adequacy and reliability of controls	No engineering or institutional controls for this alternative.	Monitoring can demonstrate engineering controls are effective. Institutional controls are enforceable.	Containment of pond sediments uses standard remedial action approaches. Monitoring can demonstrate engineering controls are effective. Institutional controls are enforceable.	Monitoring can demonstrate engineering controls are effective. Institutional controls are enforceable.	Monitoring can demonstrate engineering controls are effective. Institutional controls are enforceable.
4. Reduction in Toxicity, Mobility, or Volume	Reduction in toxicity, mobility, or volume cannot be demonstrated.	Toxicity , volume, and mobility of DNAPL is gradually reduced by natural attenuation processes, but no significant change over the near-term is anticipated.	Mobility and volume are reduced by DNAPL recovery.	Mobility and volume are reduced by aggressive DNAPL zone treatment. Toxicity reduction after active DNAPL recovery cannot be estimated with any certainty.	Mobility and volume are reduced by excavation of pond sediments and DNAPL recovery.
5. Short-Term Effectiveness					
-Time to achieve remedial action objectives	Time to achieve objectives cannot be demonstrated.	Most objectives can be met in a relatively short time frame. Restoring the impacted groundwater zone to potential beneficial use (potable water supply) is considered technically impracticable and attainment of MCLs will not be achieved in the foreseeable future.	Most objectives can be met in a relatively short time frame. Restoring the impacted groundwater zone to potential beneficial use (potable water supply) is considered technically impracticable and attainment of MCLs will not be achieved in the foreseeable future.	Most objectives can be met in a relatively short time frame. Restoring the impacted groundwater zone to potential beneficial use (potable water supply) is considered technically impracticable. Even with the degree of treatment provided for in this alternative, the degree of improvement in groundwater quality as a function of time cannot be predicted with certainty, and attainment of MCLs is not likely to occur in the foreseeable future.	Most objectives can be met in a relatively short time frame. Restoring the impacted groundwater zone to potential beneficial use (potable water supply) is considered technically impracticable and attainment of MCLs will not be achieved in the foreseeable future.
-Protection of site remediation workers during remedial action	Implementation would not require remedial action.	Implementation would not require remedial action.	Health and safety monitoring and controls will protect workers.	Health and safety monitoring and controls will protect workers. However, the use of high-temperature steam and a complex system inherently increase potential safety risks to site remediation workers.	Health and safety monitoring and controls will protect workers.
-Protection of community during remedial action	Implementation would not require remedial action.	Implementation would not require remedial action.	Health and safety monitoring and controls will protect community.	Health and safety monitoring and controls will protect community.	Health and safety monitoring and controls will protect community.
-Protection of environment during remedial action	Implementation would not require remedial action.	Implementation would not require remedial action.	Potential environmental impacts would be managed through engineering controls.	Because of the site characteristics (i.e., proximity of the DNAPL zone to the pond and river, shallow groundwater zone, etc.), significant potential exists for undesired plume migration, contaminant redistribution, and/or adverse impacts on surface water quality.	Potential environmental impacts would be managed through engineering controls. However, considering the "stirring up" of impacted sediments during excavation in the wet, there is a potential for increased contaminant release to the 21st Street Pond during remediation.
6. Implementability					
-Technical	No technical barriers to implementation.	No technical barriers to implementation.	No technical barriers to implementation. Quality control issues related to wet construction techniques.	Steam stripping beneath the Ogden River, active rail lines, and roadway structures will present technical challenges for reliable containment of mobilized DNAPL.	No technical barriers to implementation.
-Administrative feasibility	No administrative barriers to implementability have been identified.	No administrative barriers to implementability have been identified. New State law provides mechanism for reliable institutional controls.	No administrative barriers to implementability have been identified. New State law provides mechanism for reliable institutional controls.	No administrative barriers to implementability have been identified. New State law provides mechanism for reliable institutional controls.	No administrative barriers to implementability have been identified. New State law provides mechanism for reliable institutional controls.
-Availability of services and materials	No barrier to implementability.	No barrier to implementability.	No barrier to implementability. Equipment and materials are readily available.	DUS is a specialized process and a limited number of qualified vendors are available.	No barrier to implementability. Equipment and materials are readily available.
7. Cost					
-Capital	$ -	$ -	$ 500,000	$ 50,430,000	$ 1,210,000
-O&M, including monitoring	$ -	$ 500,000	$ 1,107,000	$ -	$ 1,107,000
-Total	$ -	$ 500,000	$ 1,607,000	$ 50,430,000	$ 2,317,000

Table 4-2a
UPRR Ogden Rail Yard Feasibility Study
List of ARARs
Identification of Federal Chemical-Specific ARARs for Ogden Railyard Facility

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable/ Relevant & Appropriate	Discussion
Safe Drinking Water Act – 42 USC § 300				
National Primary Drinking Water Standards	40 CFR Part 141	Establishes health-based standards for public water systems and specifies maximum contaminant levels (MCLs).	No/Yes	Standards are relevant and appropriate because the aquifer is classified as a potential source of drinking water.
Maximum Contaminant Level Goals	40 CFR Part 141	Establishes drinking water quality goals set at levels of no-known or anticipated adverse health effects, with an adequate margin of safety.	No/Yes	Standards are relevant and appropriate because the aquifer is classified as a potential source of drinking water.
Clean Water Act – 33 USC §§ 1251-1376				
Water Quality Criteria	40 CFR Part 131	Establishes criteria for water quality based on toxicity to human health.	No/Yes	The groundwater clean-up standards will consider these criteria.
Ambient Water Quality Criteria	40 CFR Part 131	Establishes criteria for water quality based on toxicity to aquatic organisms.	No/Yes	The groundwater clean-up standards will consider these criteria.
Toxic Pollutant Effluent Standards	40 CFR Part 129	Establishes effluent standards or prohibition for certain toxic pollutants: aldrin/dieldrin, DDT, endrin, toxaphene, benzidine, and PCBs.	No/Yes	PCBs have been detected in low concentrations in 21st Street Pond sediments; therefore these standards may become applicable.

Table 4-2a
UPRR Ogden Rail Yard Feasibility Study
List of ARARs
Identification of Federal Chemical-Specific ARARs for Ogden Railyard Facility

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable/ Relevant & Appropriate	Discussion
Solid Waste Disposal Act – 42 USC §§ 6901-6907				
Criteria for the Identification and Listing of Hazardous Waste	40 CFR Part 261	Establishes solid wastes which are subject to regulation as hazardous waste under 40 CFR Parts 124, 262-265, 268, and 270.	Yes	If hazardous remediation wastes were generated as part of the remedy, the identification and listing criteria are applicable.
Requirements for Releases from Solid Waste Management Units	40 CFR Part 264, Subpart F	Establishes procedures for corrective action.	No/Yes	CERCLA is the governing regulatory framework. There are no RCRA Corrective Action requirements SWMUs that would supercede their CERCLA equivalents. Standards for treatment, storage, and disposal facilities can still be be ARARs under CERCLA if hazardous remediation wastes are managed on site.
Land Disposal Restrictions	40 CFR Part 268	Establishes maximum concentrations for hazardous constituents prior to land disposal.	Yes	LDRs will be applicable only if land disposal of generated hazardous remediation waste occurs on-site.
Clean Air Act – 42 USC §§ 7401				
National Ambient Air Quality Standards (NAAQSs)	40 CFR Part 50	Establishes primary and secondary NAAQS for six pollutants: PM_{10}, SO_2, CO, ozone, NO_2, and lead.	Yes	Emissions from remedial activities shall be controlled to prevent exceedance of NAAQS for the six listed pollutants.
New Source Performance Standards (NSPS)	40 CFR Part 60	Establishes performance standards for certain types of new stationary sources.	No/Yes	Applicable only if the design of the remedy selected incorporates discharge points that trigger the emission standards of this rule.
National Emissions Standards for Hazardous Air Pollutants (NESHAPs)	40 CFR Part 61	The USEPA is required under Section 112 of the Clean Air Act to develop NESHAPs for major and area sources of hazardous air pollutants. EPA is required to control 188 Hazardous Air Pollutants (HAPs).	No/Yes	Regulation could be relevant and appropriate to remediation approaches involving potential atmospheric discharge of HAPs present in groundwater (e.g. vinyl chloride).

Table 4-2b
UPRR Ogden Rail Yard Feasibility Study
List of ARARs
Identification of State Chemical-Specific ARARs for Ogden Railroad Facility

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable/ Relevant & Appropriate	Discussion
Utah Safe Drinking Water Act – Title 19 UCA Chapter 4;Subsection 104				
Utah Primary Drinking Water Standards	R309-200-5 UAC	Establishes maximum contaminant levels for inorganic and organic chemicals as primary drinking water standards.	No/Yes	Primary drinking water maximum containment levels (MCLs) and maximum containment level goals (MCLGs) are relevant and appropriate requirements for groundwater cleanup at Superfund sites where groundwater is a potential source of drinking water.
Utah Solid and Hazardous Waste Act – Title 19 UCA Chapter 6 Part 1				
Criteria for the Identification and Listing of Hazardous Waste	R315-2- UAC	Establishes solid wastes that are regulated as hazardous wastes under the Utah Solid and Hazardous Waste Act. Definitions and exclusions of wastes that are "hazardous" are addressed in Sections 2-3 and 2-4, respectively. State regulations "mirror" federal definitions and exclusions.	Yes	Any wastes generated during the remediation phase will need to be evaluated to determine the applicability of these regulations.
Land Disposal Restrictions	R315-13 UAC	Outlines land disposal restrictions for hazardous waste. Utah incorporates Federal LDRs by reference.	Yes	Land disposal restrictions are applicable to the remedial action only if land disposal of hazardous remediation waste occurs on-site.

Table 4-2b
UPRR Ogden Rail Yard Feasibility Study
List of ARARs
Identification of State Chemical-Specific ARARs for Ogden Railroad Facility

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable/ Relevant & Appropriate	Discussion
Utah Water Quality Act – Title 19 UCA Chapter 5				
Water Quality Standards	R317-2-UAC	Establishes standards for the quality of surface waters in the State.	Yes	These rules are specific to Utah, although they are derived, in part, from federal criteria.
Ground Water Quality Standards	R317-6-2 UAC	Ground water quality standards are numerical contaminant concentration levels that are adopted for the protection of subsurface water of the State. They are defined in Table 1 of R317-6-2 UAC and with few exceptions (i.e., lead and copper) they are the same as drinking water MCLs.	Yes	These standards are applicable to ground water cleanup actions through their use as Corrective Action Concentration Limits under R317-6-6.15.F.1 UAC.
Ground Water Class Protection Levels	R317-6-4 UAC	Ground water class protection levels are pollutant concentration limits, set by ground water class for the operation of facilities that discharge or would probably discharge to ground water (R317-6-4.1.A UAC).	Yes	Protection levels could be applicable standards if the implementation of a CERCLA remedy resulted in some kind of discharge to ground water, particularly uncontaminated or minimally contaminated ground water. The ground water class protection levels are not intended to be considered as applicable or relevant and appropriate cleanup standards for contaminated ground water under any state or federal Superfund action (R317-6-6.15 UAC).
Corrective Action Concentration Limits	R317-6-6.15.F UAC	Corrective action concentration limits are standards for ground water cleanup. For contaminants that have ground water quality standards, the corrective action concentration limits are the same as the ground water quality standards. For contaminants that do not have quality standards, the corrective action concentration limits are determined site-specifically.	Yes	Applicable to groundwater cleanup in the State of Utah.

Table 4-2b
UPRR Ogden Rail Yard Feasibility Study
List of ARARs
Identification of State Chemical-Specific ARARs for Ogden Railroad Facility

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable/ Relevant & Appropriate	Discussion
Underground Injection Control (UIC) Standards	R317-7 UAC	Establishes general requirements, definitions, permitting procedures, and operating standard. UIC standards adopt by reference the federal UIC regulations with the exception of a 2-mile radius from the borehole instead of a one quarter-mile radius from the borehole to an underground source of drinking water.	Yes	The UIC regulations would be applicable for remedial activities that involve injection of treated or amended water. State counterpart to 40 CFR Parts 144-147.
Water Quality Standards	R317-8 UAC	The State of Utah implements the federal Storm Water portions of the NPDES requirements of 40 CFR Part 122. Additionally, this rule addresses point source discharges to a surface water body.	Yes	Dependent upon the S.I.C. classification of the Northern Area OU 1 and the total amount of disturbed acreage involved in the implementation of the remedy selected, the requirements of this rule will apply. Also, this rule would apply if chosen remedial alternatives include a point source discharge to a surface water body (e.g. from a pump and treat system).

Table 4-2b
UPRR Ogden Rail Yard Feasibility Study
List of ARARs
Identification of State Chemical-Specific ARARs for Ogden Railroad Facility

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable/ Relevant & Appropriate	Discussion
Utah Air Conservation Act – Title 19 UCA Chapter 2				
General Air Quality Requirements	R307-101 UAC	General air quality requirements for Utah.	Yes	Emissions from remedial activities shall be controlled to prevent exceedance of NAAQS for the six listed pollutants.
Establishes air quality standards for Utah: including general emission standards, stationary sources, and PM10 standards for particulates.	R307-201 UAC R307-210 UAC R307-305 UAC	Establishes air quality standards for visible emissions, PM_{10} non-attainment areas, emissions from internal combustion engines, new source performance standards (NSPS).	Yes	Applicable only if the design of the remedy selected incorporates discharge points that trigger the emission standards of this rule.
Fugitive Dust Emission Standards	R307-2305 UAC R307-309 UAC	Establishes fugitive dust emission standards for Ogden City and outlying areas.	Yes	Fugitive dust emissions generated during remedial action construction activities will be subject to these standards. All of the Ogden Railroad facility lies within Weber County, and a very small area lies within Ogden City limits.
National Emission Standards for Hazardous Air Pollutants (NESHAPs) as Implemented by Utah	R307- 214UAC	The USEPA is required under Section 112 of the Clean Air Act to develop NESHAPs for major and area sources of hazardous air pollutants. EPA is required to control 188 Hazardous Air Pollutants (HAPs).	No/Yes	Regulation could be relevant and appropriate to remediation approaches involving potential atmospheric discharge of HAPs present in groundwater (e.g. vinyl chloride).

Table 4-2c
UPRR Ogden Rail Yard Feasibility Study
List of ARARs
Identification of State and Federal Location-Specific ARARs for Ogden Railroad Facility

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable/ Relevant & Appropriate	Discussion
Solid Waste Disposal Act – 42 USC §§ 6902-6987				
Location Standards for Hazardous Waste Management Units	R315-8-2.9 UAC 40 CFR § 264.18	Establishes site characteristics which are unsuitable for location of hazardous waste management units.	No/Yes	Standard is an ARAR for the Ogden Railroad Facility remediation only if the remedy chosen results in the creation of a hazardous waste management unit(s).
Federal Conservation Statutes – 16 USC §§ 461-1531				
Historic Sites, Building and Antiquities Act	16 USC Sec. 461-467 40 CFR Sec. 6.301(a)	Requires federal agencies to consider the existence and location of landmarks on the National Registry of Natural Landmarks to avoid undesirable impacts upon such landmarks.	Yes	Proposed activities will not adversely affect natural landmarks.
National Historic Preservation	16 USC Sec. 470 40 CFR Sec. 6.301(b)	Requires federal agencies to take into account the effect of and federally-assisted undertaking or licensing on any district, site, building, structure, or object that is included in or eligible for inclusion in the national register of historic places.	Yes	Proposed activities will not adversely affect historical district, site, building, structure, or object.
Archaeological and Historic Preservation	16 USC Sec. 469 UCA Title 9 Chapter 8; UAC R212	Established procedures to provide for preservation of historical and archaeological data that might be destroyed through alteration of terrain as a result of a federal construction project or a federally-licensed activity or program. Preservation of archaeological, anthropological, or paleontological landmarks is provided for by state law.	Yes	Proposed activities will not adversely affect archaeological data or landmarks.
Fish and Wildlife Coordination Act	16 USC Sec 1531, et seq. 40 CFR 6.302(g)	This statute and its implementing regulations require that federal agencies or federally funded projects ensure that any modification of any stream or other water body affected by any action authorized or funded by the federal agency provides for adequate protection of fish and wildlife resources.	Yes	

Table 4-2c
UPRR Ogden Rail Yard Feasibility Study
List of ARARs
Identification of State and Federal Location-Specific ARARs for Ogden Railroad Facility

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable/ Relevant & Appropriate	Discussion
Endangered Species Act	16 USC Sec. 1531 40 CFR 6.302(h) 50 CFR 17 and 402	This statute and its implementing regulations provide that federal activities not jeopardize the continued existence of any threatened or endangered species.	Yes	
Migratory Bird Treaty Act	16 USC Sec. 703, et seq.	This requirement establishes a federal responsibility for the protection of the international migratory bird resource and requires continued consultation with the U.S. Fish and Wildlife Service during remedial design and remedial construction to ensure that the cleanup of the Site does not unnecessarily impact migratory birds.	Yes	
Bald Eagle Protection Act	16 USC Sec. 668, et seq.	This requirement establishes federal responsibility for protection of bald and golden eagles and requires continued consultation with the U.S. Fish and Wildlife Service during remedial design and remedial construction to ensure that any cleanup of the Site does not unnecessarily adversely affect the bald and golden eagles.	Yes	
Floodplain Management Regulations Executive Order No. 11988	40 CFR 6.302(b)	These require that actions be taken to avoid, to the extent possible, adverse effects associated with direct or indirect development of a floodplain or to minimize adverse impacts if no practicable alternative exists.	Yes	

Table 4-2c
UPRR Ogden Rail Yard Feasibility Study
List of ARARs
Identification of State and Federal Location-Specific ARARs for Ogden Railroad Facility

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable/ Relevant & Appropriate	Discussion
Protection of Wetlands	33 USC Sec. 1344	Discharge of dredged or fill materials into waters of the US is prohibited without a permit. Adverse impacts associated with the destruction or loss of wetlands and other special aquatic sites are to be avoided.	Yes	Measures will be developed during RD to avoid, restore, or mitigate impacts to wetlands.
	Executive Order 11990 – *Protection of Wetlands*	Directs federal agencies to take actions to minimize the destruction, loss, or degradation of wetlands and to preserve and enhance the natural and beneficial values of wetlands in carrying out the agencies' responsibilities. In addition, this Executive Order requires the agencies to consider factors relevant to a proposal's effect on the survival and quality of the wetlands.	Yes	
RCRA Subtitle C Landfill Siting Requirements – Flood Plain	40 CFR 264.18(b) UAC R315-8-2.9(b)	Any RCRA Subtitle C treatment, storage, or disposal facility that lies within a 100-year flood plain must be designed, constructed, and operated to avoid washout.	No/Yes	Relevant and appropriate for a RCRA Subtitle C landfill built at the Site where wastes are consolidated within the area of contamination (AOC).
RCRA Subtitle C Landfill Siting Requirements – Seismic	UAC R315-8-2.9(a)	A new RCRA Subtitle C treatment, storage, or disposal facility shall not be located within 200 feet of a fault that has had displacement in Holocene time.	No/Yes	Relevant and appropriate for a RCRA Subtitle C landfill built at the Site where wastes are consolidated within the AOC.
RCRA Subtitle D Landfill Siting Requirements	UAC R315-302-1 40 CFR 258	Provides location standards for a new solid waste disposal facility constructed on site.	No/Yes	Applicable only for a new solid waste landfill built at the Site.

Table 4-2d
UPRR Ogden Rail Yard Feasibility Study
List of ARARs
Identification of Federal Action-Specific ARARs for Ogden Railroad Facility

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable/ Relevant & Appropriate	Discussion
Clean Water Act – 33 USC §§ 1251-1376				
National Pollutant Discharge Elimination System Requirements	40 CFR Part 122	Establishes requirements for permits to authorize the point source discharge of pollutants into waters of the United States. Also, regulates discharges of stormwater.	Yes	Discharge of treated surface water into waters of the United States and stormwater discharges may be associated with the remediation strategy.
National Pretreatment Standards	40 CFR Part 403	Establishes standards for controlling pollutants which pass through or interfere with treatment processes in publicly owned treatment works or which may contaminate sewage sludge.	Yes	Applicable to discharges into publicly owned treatment works.
Underground Injection Control Program under the Safe Drinking Water Act	40 CFR Parts 144-147	Establishes regulations for the subsurface emplacement of fluids through an injection well.	Yes	The UIC regulations would be applicable for remedial activities that involve injection of surfactants, steam injection, or soil flooding.
Solid Waste Disposal Act – 42 USC §§ 6901-6987				
Standards Applicable to Generators of Hazardous Waste	40 CFR Part 262	Establishes requirements for generators of hazardous waste including waste characterization, pre-transport, manifesting, recordkeeping and reporting.	Yes	This rule will be applicable only if hazardous waste will be generated during remedial activities.
Standards Applicable to Waste Piles	40 CFR 264.554	Staging pile requirements for remediation wastes.	Yes	This rule will be applicable if remediation waste is managed and stored in piles on-site.

Table 4-2e
UPRR Ogden Rail Yard Feasibility Study
List of ARARs
Identification of State Action-Specific ARARs for Ogden Railroad Facility

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable/ Relevant & Appropriate	Discussion
UCA 73-3-25				
Well Drilling Standards	R655-4 UAC	Establishes standards for drilling and abandonment of wells.	Yes	If the selected remedy includes ground water monitoring /extraction well(s) or the abandonment of existing wells, the standards are applicable and relevant for the Ogden Railroad Facility.
Utah Air Conservation Act – Title 19 UCA Chapter 2				
Definitions and General Requirements for Air Conservation	R307-101 and R307-102 UAC	Outlines general requirements and provides definitions for Utah Air Conservation rules.	Yes	General requirements and definitions will be applicable for remediation strategies which include pollutant emissions.
Standards of Performance for New Stationary Sources	R307-210 UAC	Establishes standards for the performance of new stationary sources (NSPS).	No/Yes	Applicable only if the design of the remedy selected incorporates discharge points that trigger the emission standards of this rule.
National Emission Standards for Hazardous Air Pollutants (NESHAPs) as implemented by Utah	R307-214 UAC	The USEPA is required under Section 112 of the Clean Air Act to develop NESHAPs for major and area sources of hazardous air pollutants. EPA is required to control 188 Hazardous Air Pollutants (HAPs).	No/Yes	Regulation could be relevant and appropriate to remediation approaches involving potential atmospheric discharge of HAPs present in groundwater (e.g. vinyl chloride).

Table 4-2e
UPRR Ogden Rail Yard Feasibility Study
List of ARARs
Identification of State Action-Specific ARARs for Ogden Railroad Facility

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable/ Relevant & Appropriate	Discussion
Continuous Emission Monitoring System Requirements	R307-170 UAC	Establishes continuous emission monitoring system requirements for those air emission sources subject to this rule.	No/Yes	Remediaiton systems that have air emissions may be required to install continuous monitoring systems in accordance with this rule.
Davis, Salt Lake and Utah Counties and Ogden City, and Non-Attainment Area s for PM-10: Particulates.	R307-305 UAC	Establishes limits on emissions that are for the formation of (point source) PM-10 (particulates) in the designated areas (Ogden City). Ogden City is included as a target area for this regulation.	Yes	If the chosen remedy has a potential for particulate emissions, the remediation system(s) may have emissions that are subject to this regulation.
Davis, Salt Lake and Utah Counties, Ogden City and any Non-Attainment Area for PM-10: Fugitive Emissions and Fugitive Dust.	R307-309 UAC	Establishes limits on emissions that are for the formation of (fugitive source) PM-10 (particulates) in the designated areas (Ogden City). Ogden City is included as a target area for this regulation.	Yes	If the chosen remedy has a potential for generating particulate emissions as fugitive emissions or dust, the remediation activities may have emissions that are subject to this regulation.
Utah Air Quality Permits; Notice of Intent Approval Orders and Associated Emissions Impact Analysis	R307-401 UAC R307-410 UAC	Outlines general requirements for submission of a Notice of Intent to construct, modify, or relocate a stationary source of air pollution and requirements for Emissions Impact Analysis.	Yes	These rules are applicable only if remedial technologies anticipated for the Ogden Railroad facility require installation of a stationary source; thus triggering the requirements of those rules.
Small Source Exemption – De Minimis Emission Standards	R307-413-2 UAC	Lists de minimis emission standards for air pollutants.	Yes	If on-site emissions are small enough to qualify for an exemption from the requirements of R307-401, then these standards apply. An exemption would have to be justified based on an assessment of potential emissions associated with remedial activities.
Utah Solid and Hazardous Waste Act – Title 19 UCA Chapter 6 Part 1				
Definitions and General Requirements for Solid and Hazardous Waste	R315-1 and R315-2 UAC	Outlines general requirements and provides definitions for Utah Solid and Hazardous Waste Regulations.	Yes	General requirements and definitions will be applicable for the management of solid and/or hazardous waste., if generated during the remediation process.

Table 4-2e
UPRR Ogden Rail Yard Feasibility Study
List of ARARs
Identification of State Action-Specific ARARs for Ogden Railroad Facility

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable/ Relevant & Appropriate	Discussion
Hazardous Waste Generator Requirements	R315-5 UAC	Outlines requirements for generators of hazardous waste.	Yes	Generator requirements will be applicable for any and all hazardous waste generated during remediation.
Standards for Owners or Operators of Hazardous Waste Treatment Storage and Disposal Facilities (TSDFs)	R315-8 UAC	Establishes standards for Owners and Operators of TSDFs.	Yes	Applicable only if on-site generation, treatment, storage or disposal of hazardous remediation wastes would result from a chosen remedy.
Security Standards for Hazardous Waste Treatment, Storage and Disposal Facilities (TSDFs)	R315-8-2.5 UAC	Outlines security requirements at active portions of a TSDF. Establishes minimum requirements to prevent unauthorized access by persons or livestock into an active portion of a TSDF and describes other security procedures.	Yes	Applicable only if on-site generation, treatment, storage or disposal of hazardous remediation wastes would result from a chosen remedy.
General Inspection Requirements	R315-8-2.6 UAC	Establishes the requirements that owners/operators of a TSDF inspect their facilities to minimize potential unplanned releases of hazardous waste constituents to the environment.	Yes	Applicable only if on-site generation, treatment, storage or disposal of hazardous remediation wastes would result from a chosen remedy.
Personnel Training	R315-8-2.7 UAC	Describes training requirements for TSDF staff.	Yes	Applicable only if on-site generation, treatment, storage or disposal of hazardous remediation wastes would result from a chosen remedy.

Table 4-2e
UPRR Ogden Rail Yard Feasibility Study
List of ARARs
Identification of State Action-Specific ARARs for Ogden Railroad Facility

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable/ Relevant & Appropriate	Discussion
General Requirements for Ignitable, Reactive, or Incompatible Waste	R315-8-2.8 UAC	Outlines requirements to prevent accidental ignition or reaction of ignitable or reactive wastes at TSDFs.	Yes	Applicable only if on-site generation, treatment, storage or disposal of ignitable, reactive, or incompatible remediation wastes would result from a chosen remedy.
Construction Quality Assurance Program	R315-8-2.10 UAC	Establishes the requirement for a Construction Quality Assurance Program for all landfill , surface impoundment or waste pile units, including liners and final cover systems.	Yes	The preparation and implementation of a Construction Quality Assurance Program will be required only if the remedy chosen for the Ogden Railroad Facility involves these types of units and remedial construction activities.
Preparedness and Prevention	R315-8-3 UAC	Outlines TSDF facility design requirements, required equipment testing and maintenance of equipment, communication and alarm systems, aisle space requirements, and arrangements with local authorities in the event of an accidental release.	Yes	Applicable only if on-site generation, treatment, storage or disposal of hazardous remediation wastes would result from a chosen remedy.
Contingency Plan and Emergency Procedures	R315-8-4 UAC	Outlines the requirements for development of contingency plans and establishment of emergency procedures for hazardous wastes.	Yes	Applicable only if on-site generation, treatment, storage or disposal of hazardous remediation wastes would result from a chosen remedy.
Groundwater Protection	R315-8-6 UAC	Describes groundwater monitoring requirements for TSDFs.	Yes	Applicable only if remedial activities involve storage, treatment, and disposal of hazardous waste at or within on-site facilities. State counterpart of 40 CFR Part 264 Subpart E. The monitoring requirements of this rule would be relevant and appropriate where hazardous remediation wastes are managed in place or consolidated within an AOC or CAMU.

Table 4-2e
UPRR Ogden Rail Yard Feasibility Study
List of ARARs
Identification of State Action-Specific ARARs for Ogden Railroad Facility

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable/ Relevant & Appropriate	Discussion
Closure and Post Closure	R315-8-7 UAC	Establishes closure and post-closure performance standards and plan requirements for TSDFs.	Yes	Applicable only if on-site generation, treatment, storage or disposal of hazardous remediation wastes would result from a chosen remedy. State counterpart to 40 CFR Part 264 Subpart G. If a chosen remedy includes an on-site landfill closure, EPA's Guidance (i.e. Directive 9234-2-04FS, October 1989) shall be followed for the various landfill closure options.
Standards for Use and Management of Containers	R315-8-9 UAC	Establishes standards for use and management of containers holding hazardous waste at TSDFs.	Yes	Applicable only if on-site generation, treatment, storage or disposal of hazardous remediation wastes would result from a chosen remedy. State counterpart of 40 CFR Part 264 Subpart I.
Standards for Use and Management of Tanks	R315-8-10 UAC	Establishes standards for use and management of tanks containing hazardous waste.	Yes	Selected remedies do not include the treatment or storage of hazardous waste in tanks. Non-hazardous tank systems will employ secondary containment for tanks.
Landfills	R315-8-14 UAC	Establishes design, operation, and management requirements for disposal of hazardous wastes in landfills.	No/Yes	This regulation will be applicable only if a remediation system requires the construction of an on-site landfill, such as where wastes are covered in place without being excavated. These standards are relevant and appropriate to hybrid landfill closures. Hybrid landfill closure requirements will be incorporated into the 21st Street Pond remedy selection (i.e. capping sediments in place).
Surface Impoundments	R315-8-11 UAC	Establishes design, operation, and management requirements for treatment, storage or disposal of hazardous wastes in surface impoundments.	Yes	This regulation will be applicable only if a remediation system requires the construction of surface impoundment(s).
Incinerators	R315-8-16 UAC	Establishes design, operation, and management requirements for miscellaneous units.	Yes	Remediation strategy presently does not contemplate onsite operation of a hazardous waste incinerator. However, incinerator standards may become applicable if low temperature thermal treatment of excavated soil is employed. State counterpart of 40 CFR Part 264 Subpart X.
Air Emissions Standards for Process Vents	R315-8-17 UAC	This regulation incorporates the requirements as found in 40 CFR Subpart AA Sections 264.1030 through 264.1036, 1990 ed.	Yes	This regulation would be applicable only if a chosen remedy would involve air emissions from process vents of equipment during treatment, storages, or disposal of hazardous waste. Such a remedial action system would need to be designed to meet these emission standards if hazardous remediation is treated, stored or disposed as

Table 4-2e
UPRR Ogden Rail Yard Feasibility Study
List of ARARs
Identification of State Action-Specific ARARs for Ogden Railroad Facility

				part of a selected remedy.
Standard, Requirement, Criteria, or Limitation	**Citation**	**Description**	**Applicable/ Relevant & Appropriate**	**Discussion**
Air Emission Standards for Equipment Leaks	R315-8-18 UAC	This regulation incorporates the requirements as found in 40 CFR Subpart BB Sections 264.1050 through 264.1065, 1990 ed.	Yes	This regulation would be applicable only if a chosen remedy would involve source recovery. Such a remedial action system would need to be designed to meet these emission standards if hazardous remediation is treated, stored or disposed as part of a selected remedy.
Corrective Action Management Unit (CAMU)	R315-8-21 UAC	Establishes requirements for designation of a CAMU for hazardous wastes generated on-site and defines management practices.	Yes	Applicable to remedial activities in which hazardous waste generated on-site is managed. Allows exemption to LDRs if clean-up goals are achieved. State counterpart of 40 CFR Part 264 Subpart S.
Clean-up Action and Risk-Based Closure Standards	R315-101 UAC	This rule establishes risk-based closure and corrective action requirements at sites where removal of hazardous constituents to background levels will not be achieved.	Yes	This rule is applicable for remedial activities including site management, corrective action, and closure.
Corrective Action Clean-up Policy for CERCLA and Underground Storage Tank (UST) Sites	R311-211 UAC	This rule addresses clean-up requirements at CERCLA and UST sites.	Yes	Remediation strategy must achieve compliance with the policy. The policy sets forth criteria for establishing clean-up standards and requires source control or removal, and prevention of further degradation. Applicable to the Ogden Railroad Facility.
Utah Water Quality Act – Title 19 UCA Chapter 5				
Definitions and General Requirements	R317-1 UAC	Details definitions and general requirements for water quality in Utah.	Yes	General requirements and definitions will be applicable for remediation strategies including point source discharges.
Design Requirements for Wastewater Collection, Treatment, and Disposal Systems	R317-3 UAC	Outlines design requirements for the collection, treatment, and disposal of domestic wastewater.	No	Treatment of domestic wastewater will not be part of remediation strategies.

Table 4-2e
UPRR Ogden Rail Yard Feasibility Study
List of ARARs
Identification of State Action-Specific ARARs for Ogden Railroad Facility

Standard, Requirement, Criteria, or Limitation	Citation	Description	Applicable/ Relevant & Appropriate	Discussion
Underground Injection Control Standards	R317-7 UAC	Establishes general requirements, definitions, permitting procedures, and operating standards. UIC standards adopt by reference the federal UIC regulations with the exception of a two-mile radius from the borehole instead of a one-quarter-mile radius from the borehole to an underground source of drinking water.	Yes	If groundwater remediation involves the injection of treated or amended ground water, UIC standards would be applicable.
Utah Pollutant Discharge Elimination System Requirements	R317-8 UAC	Establishes general requirements, definitions, permitting procedures, and criteria/standards for technology-based treatment for point source discharges of wastewater. Also establishes pretreatment standards for discharge to a POTW.	Yes	If selected alternative involves a point source discharge of wastewater, UPDES requirements would be applicable. Pretreatment standards would be applicable if selected alternative involved discharge to a POTW. Applicable pretreatment standards are set by the local POTW in accordance with its NPDES permit.

Table 6-1
UPRR Ogden Rail Yard Feasibility Study
North and South Plume Monitoring Wells

Monitoring Well	Location	Semi-Annual Groundwater Sampling[2]	Geochemical Parameters and Degradation Products[3]	Water Level Gauging
20-MW1	South Plume			X
20-MW2	South Plume			X
20-MW3D	South Plume			X
21-MW1	South Plume			X
21-MW2	South Plume	X		X
21-MW3	South Plume			X
22b-MW1	South Plume	X		X
22b-MW2D	South Plume	X		X
26-MW1	South Plume	X		X
26-MW2	South Plume			X
26-STMW-1	South Plume			X
30-MW1	South Plume			X
30-MW2	South Plume			X
30-MW3	South Plume	X		X
30-MW-3	South Plume	X		X
30-MW4	South Plume	X		X
30-MW6D	South Plume	X		X
30-MW7	South Plume	X		X
33-MP1	North Plume			X
22a-MW1	North Plume			X
22a-MW2	North Plume			X
22a-MW3	North Plume			X
22a-MW5	North Plume			X
22a-MW6	North Plume	X	X	X
22a-MW6D	North Plume		X	X
34-MW1	North Plume	X	X	X
34-MW2	North Plume	X		X
34-MW3	North Plume	X	X	X
34-MW4	North Plume	X	X	X
34-MW6	North Plume			X
34-MW7D	North Plume			X
34-MW8	North Plume	X		X
34-MW9	North Plume	X		X
34-OB-12	North Plume	X	X	X
34-OB-13	North Plume			X
34-OB-16	North Plume			X
34-OB-17	North Plume			X
34-SPMW-02	North Plume	X		X
34-SPMW-03	North Plume			X
SPRR3-MW1	North Plume			X
SPRR5-MW1	North Plume			X
35-MW1	North Plume	X	X	X
35-MW2	North Plume			X
36-MW1	North Plume			X
36-MW2	North Plume			X
36-MW7	North Plume			X
38-MW2	North Plume		X	X
38-MW4	North Plume			X
38-MW8	North Plume			X
38-MW9	North Plume			X
38-MW12	North Plume	X	X	X

[1] This is an initial list that will be re-evaluated annually based on previous data.
[2] VOC sampling.
[3] Dissolved oxygen, nitrate/nitrite, ferrous iron, manganese, sulfate, methane, ethane, and ethene.

Table 6-2
UPRR Ogden Rail Yard Feasibility Study
Key Alternative 4 Sparging Parameters, North Plume

System	Parameter	Value	Comment
In Situ Air Sparging	Well Casing Diameter (in.)	2	Engineering judgment based on literature[1]
	Well Casing Depth (ft.)	16	Assumes clay is 20 ft. bgs, and piping is buried 2 ft. bgs
	Well Screen Length (ft.)	2	Engineering judgment based on literature[1]
	Average Saturated Zone Thickness (ft)	10.5	Based on hydrographs from MW-105, MW-106, and MW-107
	Radius of Influence (ROI) (ft.)	10.5	Assumes the saturated depth to the well screen equals the ROI (i.e. air rising through the saturated zone migrates one foot laterally for every one foot of rise.)
	Effective ROI (ft.)	21	Using on/off operation, the Effective ROI was assumed to be twice the ROI
	Total number of wells	50	Based on a 2 acre treatment area and the Effective ROI
	Total length of piping, vertical (ft.)	800	Based on well casing depth and number of wells
	Total length of piping, horizontal (ft.)	1890	Based on 5 rows of wells and the distance between wells along a row
	Total length of header pipe (ft.)	168	Based on 5 rows of wells and the distance across a row
	Flowrate per each well, Q (cfm)	5	Engineering judgment based on literature[1]
	Blower Pressure (psi)	12	Conservative value based on saturated zone thickness and piping head loss
	Total Flow of Air (cfm)	125	Assumes only half the wells are operated at a time and the flowrate per each well
Soil Vapor Extraction	Well Casing Diameter (in.)	2	Engineering judgment based on literature[1]
	Well Casing (ft.)	672	Assumes half of horizontal pipe is well screen, half is casing
	Well Screen Length (ft.)	672	Assumes half of horizontal pipe is well screen, half is casing
	Average Vadose Zone Thickness	10	Based on average depth to clay (20 ft.) and average saturated zone thickness
	Extraction Well Spacing (ft., c/c)	42	Assumes extraction wells are placed at the same interval as sparging wells
	Total number of wells	4	See Figure 6-7.
	Total length of piping, horizontal (ft.)	1344	Based 4 rows of wells and length of each well
	Total length of header pipe (ft.)	126	Based on 4 rows of wells and the distance across a row
	Minimum flowrate per each well, Q (cfm)	63	Assumes each well extracts twice the flow rate of injected air
	Minimum total flowrate of blower	250	Assumes only half the wells are operated at a time and the flowrate per each well

[1] Marley, M.C., Bruell, C.J., and Hopkins, H.H. Air Sparging Technology: A Practice Update. In Situ Aeration: Air Sparging, Bioventing, and Related Remediation Processes. Battelle Press. 1995.

Table 6-3
UPRR Ogden Rail Yard Feasibility Study
Key Alternative 4 Sparging Parameters, South Plume

System	Parameter	Value	Comment
In Situ Air Sparging	Well Casing Diameter (in.)	2	Engineering judgment based on literature[1]
	Well Casing Depth (ft.)	16	Assumes clay is 20 ft. bgs, and piping is buried 2 ft. below ground surface
	Well Screen Length (ft.)	2	Engineering judgment based on literature[1]
	Average Saturated Zone Thickness (ft)	15	Based on hydrographs from MW-105, MW-106, and MW-107
	Radius of Influence (ROI) (ft.)	15	Assumes the saturated depth to the well screen equals the ROI (i.e. air rising through the saturated zone migrates one foot laterally for every one foot of rise.)
	Effective ROI (ft.)	30	Using on/off operation, the Effective ROI was assumed to be twice the ROI
	Number of wells	50	Based on a 4 acre treatment area and the Effective ROI
	Total length of piping, vertical (ft.)	800	Based on well casing depth and number of wells
	Total length of piping, horizontal (ft.)	2700	Based on 5 rows of wells and the distance between each well
	Total length of header pipe (ft.)	240	Based on 5 rows of wells and the distance across a row
	Flowrate per each well, Q (cfm)	5	Engineering judgment based on literature[1]
	Blower Pressure (psi)	15	Conservative value based on saturated zone thickness and piping head loss
	Total Flow of Air (cfm)	125	Assumes only half the wells are operated at a time and the flowrate per each well
Soil Vapor Extraction	Well Casing Diameter (in.)	2	Engineering judgment based on literature[1]
	Well Casing (ft.)	1080	Assumes half of horizontal pipe is well screen, half is casing
	Well Screen Length (ft.)	1080	Assumes half of horizontal pipe is well screen, half is casing
	Average Vadose Zone Thickness	5	Based on average depth to clay (20 ft.) and average saturated zone thickness
	Extraction Well Spacing (ft., c/c)	60	Assumes extraction wells are placed at the same interval as sparging wells
	Total number of wells	4	See Figure 6-9.
	Total length of piping, horizontal (ft.)	2160	Based 4 rows of wells and length of each well
	Total length of header pipe (ft.)	180	Based on 4 rows of wells and the distance across a row
	Minimum flowrate per each well, Q (cfm)	63	Assumes each well extracts twice the flow rate of injected air
	Minimum total flowrate of blower	250	Assumes only half the wells are operated at a time and the flowrate per each well

[1] Marley, M.C., Bruell, C.J., and Hopkins, H.H. Air Sparging Technology: A Practice Update. In Situ Aeration: Air Sparging, Bioventing, and Related Remediation Processes. Battelle Press. 1995.

Table 6-4
UPRR Ogden Rail Yard Feasibility Study
Key Alternative 5 Sparging Parameters, Treatment Wall

Parameter	Value	Comment
Well Casing Diameter (in.)	2	Engineering judgment based on literature[1]
Well Casing Depth (ft.)	14	Assumes an average depth to clay of 17 ft., horizontal piping cover of 1 ft.
Well Screen Length (ft.)	2	Engineering judgment based on literature[1]
Saturated Thickness (ft.)	8	Conservative value based on hydrographs from MW-105, MW-106, and MW-107
Radius of Influence (ROI) (ft.)	8	Assumes the saturated depth to the well screen equals the ROI (i.e. air rising through the saturated zone migrates one foot laterally for every one foot of rise.)
Effective ROI (ft.)	16	Using on/off operation, the Effective ROI was assumed to be twice the ROI
Number of wells	85	Assumes walls are composed of two rows of wells over 1400 ft.
Total Length of piping, vertical (ft.)	1190	Based on well casing depth and number of wells
Total Length of piping, horizontal (ft.)	2500	Estimated based on piping between wells and around buildings
Blower Pressure (psi)	14	Based on max saturated thickness of wells and head loss in piping.
Flowrate per each well, Q (cfm)	5	Engineering judgment based on literature[1]
Total Flow of Air (cfm)	110	Based on the max number of wells in a segment and the flowrate per each well

[1] Marley, M.C., Bruell, C.J., and Hopkins, H.H. Air Sparging Technology: A Practice Update. In Situ Aeration: Air Sparging, Bioventing, and Related Remediation Processes. Battelle Press. 1995.

Table 7-1
Detailed Analysis of Rail Yard Groundwater Alternatives
UPRR Ogden Rail Yard Feasibility Study

Evaluation Criteria	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Description	**No Action**	**MNA**	**Focused Source Removal with MNA**	**Aggressive Source Removal with MNA**	**Perimeter Groundwater Treatment**	**Aggressive Source Remediation w/ Active Groundwater Remediation**
1. Overall Protection						
-Prevents unacceptable exposure risk to current and future human populations presented by direct contact, inhalation, or ingestion of contaminated groundwater.	No. Current human exposure does not exist. Current conditions do not prevent future groundwater exposure.	Yes. Current human exposure does not exist. Future exposure is prevented through enforceable institutional controls.	Yes. Current human exposure does not exist. Future exposure is prevented through enforceable institutional controls.	Yes. Current human exposure does not exist. Future exposure is prevented through enforceable institutional controls.	Yes. Current human exposure does not exist. Future exposure is prevented through institutional controls.	Yes. Current human exposure does not exist. Future exposure is prevented through institutional controls.
-Prevents potential future groundwater plume migration as necessary to protect current beneficial uses and potential beneficial uses of groundwater at the site, and to be protective of surface water and their designated uses.	No. Monitoring data and calculations indicate the plume is not migrating, However, without continued monitoring, achievement of this objective cannot be demonstrated.	Yes. Monitoring data and calculations indicate the plume is not migrating, With continued monitoring, achievement of this objective can be demonstrated.	Yes. Monitoring data and calculations indicate the plume is not ~~migrating, With continued monitoring,~~ achievement of this objective can be demonstrated.	Yes. Monitoring data and calculations indicate the ~~plume is not migrating, With continued monitoring,~~ achievement of this objective can be demonstrated.	Yes. Monitoring data and calculations indicate the ~~plume is not migrating, With c~~ontinued monitoring, this objective can be demonstrated. The reactive wall provides added protection should the plume shift downgradient.	Yes. Monitoring data and calculations indicate the plume is not migrating, With continued monitoring, achievement of this objective can be demonstrated.
-Restore the groundwater to beneficial uses (as technically practicable).	No. Without monitoring data, this objective cannot be evaluated.	Yes. Given sufficient time, MCLs will eventually be achieved. The timeframe to achieve MCLs cannot be accurately predicted.	Yes. Given sufficient time, MCLs will eventually be achieved. The timeframe to achieve MCLs cannot be accurately predicted.	Yes. Given sufficient time, MCLs will eventually be achieved. The timeframe to achieve MCLs cannot be accurately predicted.	Yes. Given sufficient time, MCLs will eventually be achieved. The timeframe to achieve MCLs cannot be accurately predicted.	Yes. Given sufficient time, MCLs will eventually be achieved. The timeframe to achieve MCLs cannot be accurately predicted.
-Treat, contain, or remove sources of ongoing contaminant loading to the groundwater plumes.	No. Without monitoring data, this objective cannot be evaluated.	Source treatment by natural biological processes. The sewer pipe sludge is not removed.	Source treatment by natural biological processes and removal of sewer pipe sludge.	Source treatment by volatilization of VOCs, removal of sewer pipe sludge.	Source treatment by natural biological processes. The sewer pipe sludge is not removed.	Source treatment by volatilization of VOCs, removal of sewer pipe sludge.
2. Compliance with ARARs						
-Action specific ARARs	None apply.	Will be designed to meet action specific ARARs	Will be designed to meet action specific ARARs	Will be designed to meet action specific ARARs	Will be designed to meet action specific ARARs	Will be designed to meet action specific ARARs
-Chemical specific ARARs	Although ACLs may already be met, this cannot be demonstrated without monitoring	ACLs will be met.	ACLs will be met.	ACLs will be met.	ACLs will be met.	ACLs will be met.
-Location specific ARARs	Will meet all location specific ARARs.	Will meet all location specific ARARs.	Will meet all location specific ARARs.	Will meet all location specific ARARs.	Will meet all location specific ARARs.	Will meet all location specific ARARs.
3. Long-Term Effectiveness and Permanence						
-Magnitude of residual risk	No. Reduction in residual risk cannot be verified without monitoring.	Yes. Once treatment is complete, risk will be reduced to below acceptable levels.	Yes. Once treatment is complete, risk will be reduced to below acceptable levels.	Yes. Once treatment is complete, risk will be reduced to below acceptable levels.	Yes. Once treatment is complete, risk will be reduced to below acceptable levels.	Yes. Once treatment is complete, risk will be reduced to below acceptable levels.
-Adequacy and reliability of controls	No engineering controls for this alternative. No monitoring or maintenance required.	-Institutional controls will be effective during the time required for residual risk to be reduced to acceptable levels. -Monitoring can demonstrate compliance.	-Institutional controls will be effective during the time required for residual risk to be reduced to acceptable levels. -Monitoring can demonstrate compliance.	-Institutional controls will be effective during the time required for residual risk to be reduced to acceptable levels. -Monitoring can demonstrate compliance.	-Institutional controls will be effective during the time required for residual risk to be reduced to acceptable levels. - The perimeter reactive barrier provides further assurance that offsite migration of the VOC plumes will occur during the time required for natural attenuation processes to restore the entire impacted groundwater zone to potable water quality. -Monitoring can demonstrate compliance.	-Institutional controls will be effective during the time required for residual risk to be reduced to acceptable levels. -Monitoring can demonstrate compliance.
4. Reduction in Toxicity, Mobility, or Volume	No reduction of toxicity, mobility, or volume	-Toxicity , volume, and mobility reduced through natural biological processes.	-Toxicity , volume, and mobility reduced through natural biological processes. -Sludge is removed from site.	-Toxicity , volume, and mobility reduced through natural biological processes. -Sludge is removed from site and volatilization removes additional mass.	-Toxicity , volume, and mobility reduced through natural biological processes. -IAS does not address source removal.	-Toxicity , volume, and mobility reduced through volatilization. -Sludge is removed from site.
5. Short-Term Effectiveness						
-Time to achieve remedial action objectives	No. Without monitoring data, the time to achieve remedial action objectives cannot be measured.	-Most objectives can be met in a relatively short time frame. -The time to achieve site restoration to MCLs is very uncertain. While modeling indicates that it is possible for natural attenuation processes to result in attainment of MCLs in as little as ten years, it is more probable that the required timeframe is much longer (particularly without treatment of the potential source posed by sludge in the abandoned sewer line).	-Most objectives can be met in a relatively short time frame. -The time to achieve site restoration to MCLs is very uncertain. While modeling indicates that it is possible for natural attenuation processes to result in attainment of MCLs in as little as ten years, it is more probable that the required timeframe is much longer.	-Most objectives can be met in a relatively short time frame. -The time to achieve site restoration to MCLs is very uncertain. Aggressive source area treatment likely reduces the time required to achieve site restoration to MCLs, but there is much uncertainty regarding the magnitude of the reduction. The uncertainty results from a number of factors that include the potential presence of DNAPL "pockets" (not practically identifiable), the reverse diffusion phenomenon, and the fact that there are so few documented case studies (if any) of groundwater zones impacted with CVOCs that have been remediated to MCLs.	-Most objectives can be met in a relatively short time frame. -The time to achieve site restoration to MCLs is very uncertain. While modeling indicates that it is possible for natural attenuation processes to result in attainment of MCLs in as little as ten years, it is more probable that the required timeframe is much longer (particularly without treatment of the potential source posed by sludge in the abandoned sewer line).	-Most objectives can be met in a relatively short time frame. -The time to achieve site restoration to MCLs is very uncertain. Aggressive source area treatment coupled with active remediation of remaining portions of the plume very likely reduces the time required to achieve site restoration to MCLs, but there is much uncertainty regarding the magnitude of the reduction achieved through these intensive efforts. The uncertainty results from a number of factors that include the potential presence of DNAPL "pockets" (not practically identifiable), the reverse diffusion phenomenon, and the fact that there are so few documented case studies (if any) of groundwater zones impacted with VOCs that have been remediated to MCLs.
-Protection of site remediation workers during remedial action	Implementation would not require remedial action.	Health and safety monitoring and controls will protect workers.	Health and safety monitoring and controls will protect workers.	Health and safety monitoring and controls will protect workers.	Health and safety monitoring and controls will protect workers.	Health and safety monitoring and controls will protect workers.
-Protection of community during remedial action	Implementation would not require remedial action.	There are no current unacceptable risks to the community.	Health and safety monitoring and controls will protect community.	Health and safety monitoring and controls will protect community.	Health and safety monitoring and controls will protect community.	Health and safety monitoring and controls will protect community.
-Protection of environment during remedial action	Implementation would not require remedial action.	Does not increase the potential for environmental impact.	Potential environmental impacts would be managed through engineering controls.	Potential environmental impacts would be managed through engineering controls.	Potential environmental impacts would be managed through engineering controls.	Potential environmental impacts would be managed through engineering controls.
6. Implementability						
-Technical	No technical barriers to implementation.	No technical barriers to implementation.	No technical barriers to implementation.	No technical barriers to implementation.	No technical barriers to implementation.	No technical barriers to implementation.
-Administrative feasibility	No administrative barriers to implementability have been identified.	-No administrative barriers to implementability have been identified. -New State law provides mechanism for reliable institutional controls.	-No administrative barriers to implementability have been identified. -New State law provides mechanism for reliable institutional controls.	-No administrative barriers to implementability have been identified. -New State law provides mechanism for reliable institutional controls.	-No administrative barriers to implementability have been identified. -New State law provides mechanism for reliable institutional controls.	-No administrative barriers to implementability have been identified. -New State law provides mechanism for reliable institutional controls.
-Availability of services and materials	No barrier to implementability.	No barrier to implementability. Groundwater monitoring has been completed in the past at the site.	No barrier to implementability. Equipment and materials are readily available.	No barrier to implementability. Equipment and materials are readily available.	No barrier to implementability. Equipment and materials are readily available.	No barrier to implementability. Equipment and materials are readily available.
7. Cost						
-Capital	$ -	$ -	$ 400,000	$ 2,080,000	$ 790,000	$ 4,320,000
-O&M, including monitoring	$ -	$ 550,000	$ 550,000	$ 1,230,000	$ 1,570,000	$ 2,580,000
-Total	$ -	$ 550,000	$ 950,000	$ 3,310,000	$ 2,360,000	$ 6,900,000

APPENDIX A
TECHNOLOGY SCREENING

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 8
999 18TH STREET - SUITE 300
DENVER, CO 80202-2466
Phone 800-227-8917
http://www.epa.gov/region08

May 16, 2003

Ref: 8EPR-SR

Mr. Gary L. Honeyman
Manager - Environmental Site Remediation
Union Pacific Railroad Company
221 Hodgeman
Laramie, Wyoming 82070

Re: **Memorandum on Remedial Action Alternatives**
UPRR Railroad Facility, Ogden Utah, CERCLA-8-99-12, May 9, 2003

Dear Mr. Honeyman:

The Environmental Protection Agency (EPA) and the State of Utah Department of Environmental Quality (UDEQ) concur with the Remedial Action Alternatives as proposed in the referenced memorandum.

If you have any questions, please call Michael Storck at (801) 536-4179 or me at (303) 312-6160.

Sincerely,

J. Mario Robles

J. Mario Robles
Remedial Project Manager

cc: Michael Storck, UDEQ
Hoyt Sutphin, TFG

RAA Concurrence.wpd

THE FORRESTER GROUP
INSIGHTFUL ENVIRONMENTAL SOLUTIONS

May 9, 2003

Mr. J. Mario Robles
Environmental Scientist
USEPA, Region VIII, 8EPR-SR
999 18th Street, Suite 500
Denver, Colorado 80202

MEMORANDUM ON REMEDIAL ACTION ALTERNATIVES - DRAFT
UPRR RAILROAD FACILITY, OGDEN UTAH, CERCLA-8-99-12

Dear Mr. Robles:

On April 17, 2003, the UPRR project team met with USEPA and UDEQ representatives to discuss and reach a consensus on various topics associated with the UPRR Ogden railroad facility. One of the topics of discussion was the Remedial Action Alternatives that would be evaluated in the Feasibility Study. The attached memorandum lists the proposed remedial action objectives for the site. Once we have agreement on these from the regulatory agencies, they will be incorporated into the revised 2003 Site Management Plan.

Please contact me at (303-456-0400) if you have any questions regarding this submittal.

Sincerely,

Hoyt Sutphin

Hoyt Sutphin
Project Manager

Attachment
Copy to: Michael Storck, UDEQ
Gary Honeyman, UPRR
Keith Piontek, Forrester Group

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THE FORRESTER GROUP
"INSIGHTFUL ENVIRONMENTAL SOLUTIONS"

REMEDIAL ACTION ALTERNATIVES (DRAFT)

OGDEN RAIL YARD SITE (CERCLA-8-99-12)

May 6, 2003

This document presents a listing and description of the Remedial Action Alternatives that will be evaluated to achieve the Remedial Action Objectives (RAOs) for the UPRR Ogden Rail Yard Site. Remedial Action Alternatives are described below for each of the two currently identified Operable Units at the site with established RAOs.

INTRODUCTORY NOTES

1. Remedial action alternatives have been discussed among UPRR, USEPA, and the Utah DEQ at two meetings, the November 6, 2002 meeting and the April 17, 2003 meeting. This document presents the remedial action alternatives that were agreed to through these discussions.

2. After USEPA and Utah DEQ concurrence on the information presented herein, these remedial action alternatives will be incorporated into the 2003 Site Management Plan (which is currently undergoing revision). The discussion of remedial action alternatives will be incorporated into Section 6 of the Site Management Plan (Project Tasks).

3. The Site Management Plan (containing the remedial action alternatives discussion as discussed above) will meet the requirement for submittal of a "Memorandum on Development and Preliminary Screening of Alternatives, Assembled Alternatives Screening Results and Final Screening (Administrative Order on Consent for Remedial Investigation/Feasibility Study, U.S. EPA Docket No. CERCLA-8-99-12, Paragraph 37.e.(2)).

NORTHERN AREA (OU-01)

Remedial Action alternatives to be evaluated for the Northern Area OU are as follows:

1. No Further Action.

2. Interim actions implemented to date, and long-term groundwater monitoring. Actions implemented to date include the fence around the DNAPL-impacted sediments, pond water level management, and limited DNAPL recovery. Additional groundwater sampling will be conducted to monitor DNAPL-related contaminant levels in groundwater. This alternative will also include institutional controls (details to be defined in the FS process).

3. Pond sediment remediation with DNAPL recovery. Screening and refinement of the pond sediment remedies previously presented in the Focused Feasibility Study (FFS) will be performed to identify the preferred remedy for the DNAPL-impacted sediments in the 21st Street Pond.[1] It is anticipated that the alternative that will emerge from this further evaluation will be a modification of the "sediment containment" alternative presented in the FFS. A DNAPL recovery alternative based on the results of the DNAPL recovery pilot test and the additional DNAPL zone characterization work will be developed. It is also anticipated that this alternative will focus on application of the dual phase recovery method (the technology successfully used in the pilot test) in stratigraphic lows where potentially mobile (and recoverable) DNAPL exists in the greatest quantities. Additional groundwater sampling will be conducted to monitor DNAPL-related contaminant levels in groundwater. This alternative will also include institutional controls (details to be defined in the FS process).

4. Pond sediment remediation with intensive DNAPL zone treatment. This alternative will incorporate a more intensive DNAPL zone treatment approach that maximizes reduction of contaminant mobility, volume, and toxicity, with the goal of full restoration of groundwater beneficial use as expeditiously as possible. It is anticipated that either dynamic underground stripping (a steam technology) will be the primary DNAPL removal technology incorporated into the alternative, and that this technology may need to be coupled with another technology (i.e. groundwater extraction and treatment) as the "polishing step" needed to attempt complete and expeditious restoration of the impacted groundwater zone.

[1] Focused Feasibility Study for Interim Remedial Action, Ogden Rail Yard, 21st Street Pond, Ogden, Utah (*DRAFT*), September 21, 2001, The Forrester Group, Chesterfield, MO. This document was submitted to the regulatory agencies for information purposes only. This document has not been reviewed or approved by the regulatory agencies.

OGDEN RAIL YARD GROUNDWATER (OU-04)

Remedial Action Alternatives to be evaluated for the Rail Yard Groundwater OU are as follows:

1. No further action.

2. Monitored Natural Attenuation (MNA). Evaluation of this alternative will incorporate the results of the additional groundwater monitoring and natural attenuation characterization work previously discussed.[2] This alternative will also include institutional controls (details to be defined in the FS process).

3. Source area remediation with MNA. This alternative will include actions to address the wastewater sewer lines associated with the former Southern Pacific Railroad (SP) facilities, which appear to be a potential source of ongoing CVOC loading to the North CVOC Plume. It is anticipated that this alternatives will include either cleaning or plugging of the sewer lines. This alternative will also include institutional controls (details to be defined in the FS process).

4. Aggressive Source Area Remediation with MNA. This alternative will include actions to more aggressively treat potential sources of ongoing CVOC loading to the North CVOC Plume. It is anticipated that air sparging/SVE in the zones of highest CVOC concentration will be the technology that will be incorporated into this alternative. This alternative will also include institutional controls (details to be defined in the FS process).

5. Perimeter groundwater treatment. This alternative will include actions to actively treat groundwater along the site perimeter, to mitigate the potential for offsite migration of CVOC-impacted groundwater. It is anticipated that this measure will be comprised of a line of air sparging wells that will create a treatment zone through which impacted groundwater must pass before offsite migration. This alternative will also include institutional controls (details to be defined in the FS process).

[2] The Site Management Plan will contain a discussion of the additional groundwater monitoring that will be performed pursuant to the FS process.

6. Aggressive source area remediation and active groundwater remediation. The objective of this alternative is restoration of groundwater beneficial use as expeditiously as possible. This alternative will include the source area remediation approach from Alternative 4, and will be coupled with active remediation (air sparging and/or groundwater extraction and treatment) of remaining portions of the groundwater plume as needed to attempt complete and expeditious restoration of the impacted groundwater zone.

The Forrester Group
ENVIRONMENTAL MANAGEMENT & PLANNING

November 8, 2001

FILE COPY

Mr. J. Mario Robles
USEPA, 8EPR-SR
999 18th Street, Suite 500
Denver, CO 80202-2466

IDENTIFICATION OF CANDIDATE TECHNOLOGIES – NORTHERN AREA
UPRR OGDEN RAIL YARD
CERCLA 8-99-12

Dear Mr. Robles:

On behalf of Union Pacific Railroad (UPRR), The Forrester Group has completed an initial screening of technologies that appear to be the most likely candidates for implementation at the Northern Area operable unit of the Ogden rail yard. The identification of candidate technologies is based upon what is currently known about site conditions. The list of technologies may change in the future as a result of additional data collection and the results of the human health and ecological risk assessment.

The format of this screening follows the format used in the June 2000 screening of technologies for the entire rail yard site. Please forward any comments to me after your review of this document.

Sincerely,

Hoyt Sutphin
Project Manager

Enclosure
Copy to: M. Storck, UDEQ
G. Honeyman, UPRR
K. Piontek, TFG
D. Romankowski, TFG

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OGDEN RAIL YARD
ALTERNATIVES IDENTIFICATION AND EVALUATION PROCESS
IDENTIFICATION OF CANDIDATE TECHNOLOGIES – NORTHERN AREA

November 5, 2001

This document presents the results of a screening of remedial action technologies for the Northern Area Operable Unit.

Objectives

The objectives of the technology screening are as follows:

- Identify the remedial action technologies that will be carried forward for evaluation in the Feasibility Study.
- Identify the technologies that require treatability testing to support the Feasibility Study process, particularly with respect to remedy selection.

Scope and Methodology

Based on the results presented in the draft/final *Remedial Investigation Report, Ogden Rail Yard, Northern Area*, the technology screening focused on the following media and/or conditions of concern:

- DNAPL zone
- Impacted sediments
- Impacted groundwater

For each candidate technology, the screening considered two questions:

- Considering site conditions and the niche of the technology, is the technology potentially applicable to the site?

- If the technology is potentially applicable, is there sufficient existing information to sufficiently evaluate its applicability in the Feasibility Study (i.e., to support remedy selection)?

Results

Results of the technology screening are presented in the attached table. Generally, for the technologies that are potentially applicable, there is sufficient existing data and information to support remedy selection in the Feasibility Study process. The exception is with respect to primary and secondary DNAPL recovery techniques (conventional gravity recovery and water-flood recovery). Pilot testing is required to evaluate the recoverability of DNAPL using these techniques, and to project how these techniques would be applied to the site.

There are a number of other advanced DNAPL zone remediation technologies (e.g., tertiary recovery techniques such as surfactant flooding) that would require pilot testing before implementation, to establish design parameters. However, there is sufficient information to evaluate these technologies in the FS process. Considering the scope and cost of pilot testing for these advanced technologies, the appropriate time for pilot testing of these technologies (as necessary) is after remedy selection and as a component of subsequent remedy design and implementation.

OGDEN RAIL YARD
ALTERNATIVES IDENTIFICATION AND EVALUATION PROCESS
IDENTIFICATION OF CANDIDATE TECHNOLOGIES – NORTHERN AREA

POTENTIALLY AFFECTED MEDIA AND TECHNOLOGIES			APPLICABILITY		
Medium	General Response Action	Candidate Technology	Does This Technology Potentially Apply to Site?	Following the RI Will There Be Sufficient Data to Evaluate in the FS?	COMMENTS
Sediments (21st Street Pond)	Access Restrictions	Fences	yes	yes	Completed in May 2001 as an interim action
		Increase water depth above sediments	yes	yes	Completed in Summer 2001 as an interim action
		Institutional controls	yes	yes	
	Containment	Native soil cap	yes	yes	
		Clay cap	yes	yes	
		Synthetic membrane	yes	yes	
		Asphalt or concrete cap	yes	yes	
		Multilayered cap	yes	yes	
	Excavation and Removal	Mechanical excavation	yes	yes	
		Dewatering	yes	yes	
	Soil Treatment	Stabilization	yes	yes	
		Incineration	yes	yes	
		Bioremediation	yes	yes[1]	
		Thermal desorption	yes	yes[1]	
	Disposal	Reapplication	yes	yes	
		Consolidation on site in a designed cell	no	--	Not justified by the incremental cost relative to off-site disposal
		Off-site disposal	yes	yes	
Groundwater	Monitored Natural Attenuation	Monitored natural attenuation	yes	yes	
	Access Restrictions	Institutional controls	yes	yes	

OGDEN RAIL YARD
ALTERNATIVES IDENTIFICATION AND EVALUATION PROCESS
IDENTIFICATION OF CANDIDATE TECHNOLOGIES – NORTHERN AREA

POTENTIALLY AFFECTED MEDIA AND TECHNOLOGIES			APPLICABILITY		
Medium	General Response Action	Candidate Technology	Does This Technology Potentially Apply to Site?	Following the RI Will There Be Sufficient Data to Evaluate in the FS?	COMMENTS
Groundwater	Containment	Soil-bentonite slurry wall	yes	yes	
		Cement-bentonite slurry wall	yes	yes	
		Grout curtains	yes	yes	
		Sheet-pile wall	yes	yes	
		Sorptive barrier	yes	yes	
	Collection	Vertical wells	yes	yes	
		Horizontal wells	yes	yes	
		Horizontal drainlines	yes	yes	
	Ex-Situ Treatment	Aerobic bioreactor	yes	yes[1]	
		Granular activated carbon	yes	yes	
		Chemical/UV oxidation	yes	yes	
		Air stripping	no	--	Not applicable to primary constituents of concern
		Filtration	no	--	Not applicable to primary constituents of concern
		Ion exchange/adsorption	no	--	Not applicable to primary constituents of concern
		Precipitation	no	--	Not applicable to primary constituents of concern
	In-Situ Biological Treatment	Aerobic cometabolic biodegradation	no	--	Not applicable to primary constituents of concern
		Aerobic bioremediation	yes	yes[1]	
		Anaerobic bioremediation	yes	yes[1]	
		Phytoremediation	yes	yes[1]	
	In-Situ Physical-Chemical Treatment	Pneumatic fracturing	no	--	Not applicable to site subsurface conditions
		Hydraulic fracturing	no	--	Not applicable to site subsurface conditions
		Air sparging	no	--	Not applicable to primary constituents of concern
		Electrokinetic treatment	no	--	Not applicable to primary constituents of concern or site subsurface conditions
		Passive treatment walls	yes	yes[1]	
		Chemical oxidation	yes	yes[1]	
		Chemical reduction	no	--	Not applicable to primary constituents of concern
	Discharge	NPDES permitted	yes	yes	
		POTW permitted	yes	yes	

OGDEN RAIL YARD
ALTERNATIVES IDENTIFICATION AND EVALUATION PROCESS
IDENTIFICATION OF CANDIDATE TECHNOLOGIES – NORTHERN AREA

POTENTIALLY AFFECTED MEDIA AND TECHNOLOGIES			APPLICABILITY		
Medium	General Response Action	Candidate Technology	Does This Technology Potentially Apply to Site?	Following the RI Will There Be Sufficient Data to Evaluate in the FS?	COMMENTS
DNAPL	Monitored Natural Attenuation	Monitored natural attenuation	yes	yes	
	Access Restrictions	Institutional controls	yes	yes	
	Containment	Slurry wall	yes	yes	
		Grout/concrete curtain wall	yes	yes	
		Sorptive barrier	yes	yes	
		Sheet-pile wall	yes	yes	
	Excavation and Removal	Mechanical excavation	yes	yes	
	DNAPL Recovery	Water flood recovery	yes	yes[1]	
		Dynamic underground stripping (DUS)	yes	yes[1]	
		Surfactant/cosolvent flooding	yes	yes[1]	
		Dual phase extraction	no	–	Not applicable to primary constituents of concern
	Fluid Delivery/Recovery	Vertical wells	yes	yes	
		Horizontal wells	yes	yes	
		Horizontal drainlines	yes	yes	
	Treatment	DUS with hydrous pyrolysis oxidation (HPO)	yes	yes[1]	
		Six-phase heating	yes	yes[1]	
		Enhanced desorption and bioremediation	yes	yes[1]	
		In situ thermal destruction	yes	yes[1]	
		In situ chemical oxidation	yes	yes[1]	
		Off-site treatment	yes	yes	
	Disposal	Off-site disposal	yes	yes	

[1] Sufficient data exists to evaluate this technology in the FS. If the FS identifies this technology as part of the recommended remedy, pilot testing will be required for design

OGDEN RAILYARD
ALTERNATIVES IDENTIFICATION AND EVALUATION PROCESS
IDENTIFICATION OF CANDIDATE TECHNOLOGIES

CONTAMINANT OF CONCERN: *DNAPL HYDROCARBONS*

POTENTIALLY AFFECTED MEDIA AND TECHNOLOGIES			APPLICABILITY		
Medium	General Response Action	Candidate Technology	Does This Technology Potentially Apply to Site?	Following the RI Will There Be Sufficient Data to Evaluate in the FS?	COMMENTS
Sediments (21st Street Pond)	Access Restrictions	Excavation Restrictions	yes	yes	[Would Exc. Restrictions be part of a deed restriction?]
		Fences	yes	yes	Completed in May 2001 as an interim action
		Permits	yes	yes	[What kind of permit? Is this really a valid consideration given that UP doesn't own the pond?]
		Deed Restrictions	yes	yes	[How does this work since UP doesn't own the pond affect this candidate? Is this a viable candidate?]
	Containment	Native soil cap	yes	yes	
		Clay cap	yes	yes	
		Synthetic membrane	yes	yes	
		Asphalt or concrete cap	yes	yes	
		Multilayered cap	yes	yes	
	Excavation and Removal	Mechanical excavation	yes	yes	
		Dewatering	yes	yes	
		Consolidation in a designed cell on site	yes	yes	[Is this something we would really consider giving that the rail yard is still active?]
		Remote disposal	yes	yes	
	Soil Treatment	Stabilization	yes	yes	
		Incineration	yes	yes	
		Thermal desorption	yes	yes[1]	[This was found through the EPA webpage on presumptive remedies.]
		Biodegradation	yes	yes	
Groundwater	Monitoring	Monitored natural attenuation	yes	yes	
		Monitoring flow and contaminant concentration	yes	yes	[Is there a real difference between evaluating MNA and "monitoring flow and concentration"?]
	Access Restrictions	Deed restrictions	yes	yes	
		Permits	yes	yes	
	Containment	Soil-bentonite slurry wall	yes	yes	
		Cement-bentonite slurry wall	yes	yes	

OGDEN RAILYARD
ALTERNATIVES IDENTIFICATION AND EVALUATION PROCESS
IDENTIFICATION OF CANDIDATE TECHNOLOGIES

CONTAMINANT OF CONCERN: *DNAPL HYDROCARBONS*

POTENTIALLY AFFECTED MEDIA AND TECHNOLOGIES			APPLICABILITY		
Medium	General Response Action	Candidate Technology	Does This Technology Potentially Apply to Site?	Following the RI Will There Be Sufficient Data to Evaluate in the FS?	COMMENTS
		Grout curtains	yes	yes	
		Sheet-pile wall	yes	yes	
		Reverse-gradient extraction system.	yes	yes	[Is this something different from pump-n-treat. I am thinking of Phillips KC refinery, where containment was a secondary objective.] The hydraulic gradient at this site is already one that points into the DNAPL plume, suggesting that the DNAPL is contained on site. This technology could be used to prevent DNAPL migration should monitoring suggest the DNAPL was migrating to a receptor.
	Collection	Conventional Pump/Treat	yes	yes	
		Horizontal extraction trench	yes	yes	
	Ex-Situ Treatment with Direct POTW Discharge	Aerobic bioreactor	yes	yes[1]	
		Granular activated carbon	yes	yes	
		Chemical/UV oxidation	yes	yes	
		Air stripping	no	--	As stated in the RI, benzo(a) pyrene and naphthalene are the primary constituents of concern. Because these chemicals are both SVOCs, air stripping is not expected to be a successful technology.
		Filtration	no	--	Filtration uses physical and chemical interactions to remove suspended particles. Because the constituents of concern occur in the dissolved phase, this is not an approriate option.
		Ion exchange/adsorption	no	--	The constituents of concern are organic chemicals, not ions. Therefore this technology would likely be ineffective.
		Precipitation	no	--	Precipitation of the constituents of concern is not likely to be viable treatment option.
	In-Situ Biological Treatment	Aerobic cometabolic biodegradation	no	--	This technology generally applies to chlorinated solvents, and therefore is not appropriate for the contaminant of concern.

OGDEN RAILYARD
ALTERNATIVES IDENTIFICATION AND EVALUATION PROCESS
IDENTIFICATION OF CANDIDATE TECHNOLOGIES

CONTAINMANT OF CONCERN: *DNAPL HYDROCARBONS*

POTENTIALLY AFFECTED MEDIA AND TECHNOLOGIES			APPLICABILITY		
Medium	General Response Action	Candidate Technology	Does This Technology Potentially Apply to Site?	Following the RI Will There Be Sufficient Data to Evaluate in the FS?	COMMENTS
		Anaerobic bioremediation	yes	yes[1]	
		Phytoremediation	yes	yes[1]	
		Bioremediation Enhancements	yes	yes[1]	
	In-Situ Physical-Chemical Treatment	Pneumatic fracturing	no	--	Pneumatic fracturing is generally used for clayey and silty sols. This technology will not likely be needed because the soils at the site are generally sands and gravels.
		Hydraulic fracturing	no	--	Hydraulic fracturing should not be needed because the site soils are generally sands and gravels.
		Air sparging	no	--	The success of air sparging depends in large part on the volatility of the constituents. Because the volatility of some of the constituents of concern is low, air sparging is not expected to be a successful technology for this site.
		Electrokinetic treatment	no	--	This technology generally applies to highly ionic constituents, not the organic ones that are found at the site.
		Passive treatment walls	yes	yes[1]	
		Chemical oxidation	yes	yes[1]	[A pilot study would be needed for most all in-situ candidates, including groundwater chemical oxidation, correct?]
		Chemical reduction	no	--	Further reduction of the constituents of concern would not likely transform them into harmless byproducts.
	Disposal	Reinjection	yes	yes	
		Off-site disposal	yes	yes	
DNAPL	Access Restrictions	Excavation restrictions	yes	yes	
		Deed restrictions	yes	yes	
		Permits	yes	yes	

OGDEN RAILYARD
ALTERNATIVES IDENTIFICATION AND EVALUATION PROCESS
IDENTIFICATION OF CANDIDATE TECHNOLOGIES

CONTAMINANT OF CONCERN: *DNAPL HYDROCARBONS*

POTENTIALLY AFFECTED MEDIA AND TECHNOLOGIES			APPLICABILITY		
Medium	**General Response Action**	**Candidate Technology**	**Does This Technology Potentially Apply to Site?**	**Following the RI Will There Be Sufficient Data to Evaluate in the FS?**	**COMMENTS**
	Monitoring	Monitoring flow and contaminant concentration	yes	yes	[Should we change this to MNA? Some attenutation of the plume may be occurring naturally, and the monitoring of the flow and concentration would be used to assess the extent of attenuation.]
	Containment	Slurry wall	yes	yes	
		Grout/concrete curtain wall	yes	yes	
		Sorptive barrier	yes	yes	
		Sheet-pile wall	yes	yes	
		Reverse-gradient extraction system.	yes	yes	Even though the hydraulic gradients already point inward toward the DNAPL, this technology could be applied if the gradients change.
	Fluid Collection	Mechanical excavation	yes	yes	
		Gravity recovery trenches	yes	yes[1]	Passive treatment consisting of horizontal trenches
		Recovery wells	yes	yes[1]	Passive (gravity) or active (pumping) treatment of DNAPL from vertical wells
		Water Flood recovery	yes	yes[1]	Would include either recovery wells or trenches.
		Dynamic underground stripping (DUS)	yes	yes[1]	Would include extraction wells or trenches, as well as SVE
		Dual phase extraction	no	–	Generally applies to low permeability subsurfaces; therefore it is not an applicable technology to this site.
		Surfactant/cosolvent flooding	yes	yes[1]	Injection of a solution capable of enhancing transport of chemicals to either recovery wells or trenches
		Steam/hot water floodng	yes	yes[1]	Would include either recovery wells or trenches.
	Treatment	DUS with Hydrous pyrolysis oxidation (HPO)	yes	yes[1]	Reportedly removes constituents through volatilization and destruction (oxidation)
		Six-phase heating	yes	yes[1]	In situ heating and steam production improves volatilization and destruction rates.

OGDEN RAILYARD
ALTERNATIVES IDENTIFICATION AND EVALUATION PROCESS
IDENTIFICATION OF CANDIDATE TECHNOLOGIES

CONTAMINANT OF CONCERN: ***DNAPL HYDROCARBONS***

POTENTIALLY AFFECTED MEDIA AND TECHNOLOGIES			APPLICABILITY		
Medium	**General Response Action**	**Candidate Technology**	**Does This Technology Potentially Apply to Site?**	**Following the RI Will There Be Sufficient Data to Evaluate in the FS?**	**COMMENTS**
		Enhanced desorption and bioremediation	no	–	Innappropriate technology because it applies to chlorinated sovlent DNAPLs.
		In situ thermal destruction	yes	yes[1]	Boils NAPL and groundwater to destroy the contaminant in situ
		In situ chemical oxidation	yes	yes[1]	Injection of oxidizing agents to promote abiotic oxidation of contaminants.
		Passive treatment walls	yes	yes[1]	Wall media would treat DNAPL as the fluid passes through the wall gate.
		Off-site treatment	yes	yes	
	Disposal	Off-site disposal	yes	yes	

[1] Sufficient data exists to evaluate this technology in the FS. If the FS identifies this technology as part of the recommended remedy, pilot testing will be required for design.

OGDEN RAILYARD
ALTERNATIVES IDENTIFICATION AND EVALUATION PROCESS
IDENTIFICATION OF CANDIDATE TECHNOLOGIES

CONTAMINANT OF CONCERN: *DNAPL HYDROCARBONS*

POTENTIALLY AFFECTED MEDIA AND TECHNOLOGIES			APPLICABILITY		
Medium	General Response Action	Candidate Technology	Does This Technology Potentially Apply to Site?	Following the RI Will There Be Sufficient Data to Eval-uate in the FS?	COMMENTS
Sediments (21st Street Pond)	Access Restrictions	Excavation Restrictions	yes	yes	RI data adequate for evaluation (FSP 3.4; 3.6; 6.3.1; 6.3.2)
		Fences	yes	yes	RI data adequate for evaluation (FSP 3.4; 3.6; 6.3.1; 6.3.2)
		Permits	yes	yes	RI data adequate for evaluation (FSP 3.4; 3.6; 6.3.1; 6.3.2)
		Deed Restrictions	yes	yes	RI data adequate for evaluation (FSP 3.4; 3.6; 6.3.1; 6.3.2)
	Containment	Native soil cap	yes	yes	RI data adequate for evaluation (FSP 3.4; 3.6; 6.3.1; 6.3.2)
		Clay cap	yes	yes	RI data adequate for evaluation (FSP 3.4; 3.6; 6.3.1; 6.3.2)
		Synthetic membrane	yes	yes	RI data adequate for evaluation (FSP 3.4; 3.6; 6.3.1; 6.3.2)
		Asphalt of concrete cap	yes	yes	RI data adequate for evaluation (FSP 3.4; 3.6; 6.3.1; 6.3.2)
		Multilayered cap	yes	yes	RI data adequate for evaluation (FSP 3.4; 3.6; 6.3.1; 6.3.2)
		Chemical sealant/stabilizers	no(?)	yes	RI data adequate for evaluation (FSP 3.4; 3.6; 6.3.1; 6.3.2)
	Excavation and Removal	Mechanical excavation	yes	yes	RI data adequate for evaluation (FSP 3.4; 3.6; 6.3.1; 6.3.2)
		Dewatering	yes	yes	RI data adequate for evaluation (FSP 3.4; 3.6; 6.3.1; 6.3.2)
		Consolidation in a designed cell on site	yes	yes	RI data adequate for evaluation (FSP 3.4; 3.6; 6.3.1; 6.3.2)
		Remote disposal	yes	yes	RI data adequate for evaluation (FSP 3.4; 3.6; 6.3.1; 6.3.2)
	Soil Treatment	Solidification and/or stabilization	yes	yes	RI data adequate for evaluation (FSP 3.4; 3.6; 6.3.1; 6.3.2)
		Incineration	yes	yes	RI data adequate for evaluation (FSP 3.4; 3.6; 6.3.1; 6.3.2)
		Biodegradation	yes	yes	RI data adequate for evaluation (FSP 3.4; 3.6; 6.3.1; 6.3.2)
Groundwater	Monitoring	Monitored natural attenuation	yes	yes	RI data adequate for evaluation (FSP 3.5; 6.3.1)
		Monitoring flow and contaminant concentration	yes	yes	RI data adequate for evaluation (FSP 3.5; 6.3.1)
	Access Restrictions	Deed restrictions	yes	yes	RI data adequate for evaluation (FSP 3.5; 6.3.1)
		Permits	yes	yes	RI data adequate for evaluation (FSP 3.5; 6.3.1)
	Containment	Slurry wall	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Grout/concrete curtain wall	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)

OGDEN RAILYARD
ALTERNATIVES IDENTIFICATION AND EVALUATION PROCESS
IDENTIFICATION OF CANDIDATE TECHNOLOGIES

CONTAMINANT OF CONCERN: *DNAPL HYDROCARBONS*

POTENTIALLY AFFECTED MEDIA AND TECHNOLOGIES			APPLICABILITY		
Medium	General Response Action	Candidate Technology	Does This Technology Potentially Apply to Site?	Following the RI Will There Be Sufficient Data to Evaluate in the FS?	COMMENTS
		Cement-bentonite slurry wall	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Sorptive barrier	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Sheet-pile wall	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Reverse-gradient extraction system.	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Vibrating beam barrier installation	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Permeability reduction agents	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Ground freezing	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Block displacement	no(?)	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Liners	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
	Collection	Extraction wells	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2) [Why **is this adequate for GW but not for DNAPL?]**
		Extraction trench	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		One-pass Trenching	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
	Ex-Situ Biological Treatment with Direct POTW Discharge	Aerobic bioreactor	yes	yes	Sufficient data exists to evaluate this technology. If the FS identifies this technology as part of the recommended remedy, pilot testing will be required for design.
		Anaerobic bioreactor	yes	yes	Sufficient data exists to evaluate this technology. If the FS identifies this technology as part of the recommended remedy, pilot testing will be required for design.
	In-Situ Biological Treatment	Aerobic cometabolic biodegradation	no(?)	yes	
		Anaerobic bioremediation	yes	yes	Sufficient data exists to evaluate this technology. If the FS identifies this technology as part of the recommended remedy, pilot testing will be required for design.

OGDEN RAILYARD
ALTERNATIVES IDENTIFICATION AND EVALUATION PROCESS
IDENTIFICATION OF CANDIDATE TECHNOLOGIES

CONTAMINANT OF CONCERN: *DNAPL HYDROCARBONS*

POTENTIALLY AFFECTED MEDIA AND TECHNOLOGIES			APPLICABILITY		
Medium	General Response Action	Candidate Technology	Does This Technology Potentially Apply to Site?	Following the RI Will There Be Sufficient Data to Eval-uate in the FS?	COMMENTS
		Phytoremediation	yes	no	Sufficient data exists to evaluate this technology. If the FS identifies this technology as part of the recommended remedy, pilot testing will be required for design.
		Bioremediation Enhancements	yes	yes	Sufficient data exists to evaluate this technology. If the FS identifies this technology as part of the recommended remedy, pilot testing will be required for design.
	Ex-Situ Physical-Chemical Treatment with Direct POTW Discharge	Activated carbon	yes	yes	RI data adequate for evaluation (FSP 3.5; 6.3.1)
		Chemical oxidation	yes	yes	RI data adequate for evaluation (FSP 3.5; 6.3.1)
		Chemical reduction	no(?)	yes	RI data adequate for evaluation (FSP 3.5; 6.3.1)
		Air stripping	yes	yes	RI data adequate for evaluation (FSP 3.5; 6.3.1)
		Filtration	yes	no	RI data adequate for evaluation (FSP 3.5; 6.3.1)
		Ion exchange	no	yes	RI data adequate for evaluation (FSP 3.5; 6.3.1)
		Precipitation	no	yes	RI data adequate for evaluation (FSP 3.5; 6.3.1)
		Reaction wall	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
	In-Situ Physical-Chemical Treatment	Pneumatic fracturing	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Hydraulic fracturing	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Air sparging	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Electrokinetic treatment	no	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Passive treatment walls	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Chemical oxidation	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Chemical reduction	no (?)	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
	Disposal	Reinjection	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Off-site disposal	yes	yes	RI data adequate for evaluation (FSP 3.5; 6.3.1)
DNAPL	Access Restrictions	Excavation restrictions	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Deed restrictions	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Permits	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
	Monitoring	Monitoring flow and contaminant concentration	yes	yes	RI data adequate for evaluation (FSP 3.5; 6.3.1)
	Containment	Slurry wall	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)

CONTAMINANT OF CONCERN: *DNAPL HYDROCARBONS*

POTENTIALLY AFFECTED MEDIA AND TECHNOLOGIES			APPLICABILITY		
Medium	General Response Action	Candidate Technology	Does This Technology Potentially Apply to Site?	Following the RI Will There Be Sufficient Data to Evaluate in the FS?	COMMENTS
		Grout/concrete curtain wall	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Sorptive barrier	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Sheet-pile wall	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Reverse-gradient extraction system.	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Hydraulic barrier	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Reverse-gradient extraction system.	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Vibrating Beam Barrier Installation	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Permeability reduction agents	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Ground freezing	yes	yes	Sufficient data exists to evaluate this technology. If the FS identifies this technology as part of the recommended remedy, pilot testing will be required for design.
		Block displacement	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Liners	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
	Collection	Mechanical excavation	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Extraction wells	yes	yes	Sufficient data exists to evaluate this technology. If the FS identifies this technology as part of the recommended remedy, pilot testing will be required for design.
		Extraction trench	yes	yes	Sufficient data exists to evaluate this technology. If the FS identifies this technology as part of the recommended remedy, pilot testing will be required for design.
		One-pass trenching	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
	Treatment	Pretreatment & direct POTW discharge	yes (?)	yes	RI data adequate for evaluation (FSP 3.5; 6.3.1)

OGDEN RAILYARD
ALTERNATIVES IDENTIFICATION AND EVALUATION PROCESS
IDENTIFICATION OF CANDIDATE TECHNOLOGIES

CONTAMINANT OF CONCERN: *DNAPL HYDROCARBONS*

POTENTIALLY AFFECTED MEDIA AND TECHNOLOGIES			APPLICABILITY		
Medium	General Response Action	Candidate Technology	Does This Technology Potentially Apply to Site?	Following the RI Will There Be Sufficient Data to Evaluate in the FS?	COMMENTS
		Steam/hot water floodng	yes	yes	Sufficient data exists to evaluate this technology. If the FS identifies this technology as part of the recommended remedy, pilot testing will be required for design.
		Dynamic underground stripping (DUS)	yes	yes	Sufficient data exists to evaluate this technology. If the FS identifies this technology as part of the recommended remedy, pilot testing will be required for design.
		DUS with hydrous pyrolysis oxidation (HPO)	yes	yes	Sufficient data exists to evaluate this technology. If the FS identifies this technology as part of the recommended remedy,
		Six-phase heating	yes	yes	Sufficient data exists to evaluate this technology. If the FS identifies this technology as part of the recommended remedy, pilot testing will be required for design.
		Enhanced desorption and bioremediation	yes	yes	Sufficient data exists to evaluate this technology. If the FS identifies this technology as part of the recommended remedy, pilot testing will be required for design.
		In situ thermal destruction	yes	yes	Sufficient data exists to evaluate this technology. If the FS identifies this technology as part of the recommended remedy, pilot testing will be required for design.
		In situ chemical oxidation	yes	yes	Sufficient data exists to evaluate this technology. If the FS identifies this technology as part of the recommended remedy, pilot testing will be required for design.
		Surfactant/Cosolvent flooding	yes	yes	Sufficient data exists to evaluate this technology. If the FS identifies this technology as part of the recommended remedy, pilot testing will be required for design.
		Enhanced thermal recovery	yes	yes	Sufficient data exists to evaluate this technology. If the FS identifies this technology as part of the recommended remedy, pilot testing will be required for design.
		Phytoremediation	yes	yes	Sufficient data exists to evaluate this technology. If the FS identifies this technology as part of the recommended remedy, pilot testing will be required for design.

OGDEN RAILYARD
ALTERNATIVES IDENTIFICATION AND EVALUATION PROCESS
IDENTIFICATION OF CANDIDATE TECHNOLOGIES

CONTAMINANT OF CONCERN: *DNAPL HYDROCARBONS*

POTENTIALLY AFFECTED MEDIA AND TECHNOLOGIES			APPLICABILITY		
Medium	General Response Action	Candidate Technology	Does This Technology Potentially Apply to Site?	Following the RI Will There Be Sufficient Data to Evaluate in the FS?	COMMENTS
		Dual phase extraction	yes	yes	Sufficient data exists to evaluate this technology. If the FS identifies this technology as part of the recommended remedy, pilot testing will be required for design.
		Passive treatment walls	yes	yes	Sufficient data exists to evaluate this technology. If the FS identifies this technology as part of the recommended remedy, pilot testing will be required for design.
		Off-site treatment	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
	Disposal	Off-site disposal	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)

safety-kleen®

June 2, 2000

Mr. Mario Robles, 8EPR-SR
United States Environmental Protection Agency
999 18th Street, Suite 500
Denver, CO 80202-2466

RE: Ogden Railyard Selection of Candidate Technologies for Site Remediation
CERCLA 8-99-12

Dear Mr. Robles:

Safety-Kleen Consulting (SKC), on behalf of Union Pacific Railroad (UPRR), has completed an initial selection of technologies which appear to be the most likely candidates for implementation at the Ogden Railyard site. The identification of candidate technologies is based upon what is currently known about site conditions. The list of technologies may change in the future as a result of additional data collection and the results of the human health and ecological risk assessment.

The identification of candidate technologies has the purpose of determining if currently available data as well as that to be generated during the Remedial Investigation (RI) will be adequate to evaluate feasibility of technologies during the Feasibility Study (FS). Candidate technologies were identified based upon contaminants of concern and the likely media impacted by each. The contaminants of concern and their associated media are:

- Vinyl chloride (air, soil, groundwater);
- Dense nonaqueous-phase liquids (DNAPL) (air, soil, groundwater, surface water, sediment, free-phase DNAPL);
- Sludge (no associated medium);
- Diesel (air, soil, groundwater, free-phase LNAPL); and
- Metals (surface soil hot spots).

The attached table summarizes the candidate technologies for each contaminant of concern and medium. The table also indicates, based upon the information currently available, if existing information and RI data will be sufficient to evaluate each technology during the FS. For each technology the table indicates, in the "Comments" column, the sections of the Field Sampling Plan which will provide data needed to evaluate the technology. If it appears the data will not be adequate, then the table briefly describes the additional investigations, including treatability and pilot studies, that will be necessary.

UPRR and its consultants are prepared to discuss with you this summary of candidate technologies once you have completed your review.

Yours truly,

Mark L. Gallup

Mark L. Gallup, P.E.
Senior Engineer

[illegible] V. Petronoff
Senior Geologist

cc: Gary Honeyman, UPRR
Keith Piontek, Forrester Group
Tom Sale
Michael Storck, UTDEQ

OGDEN RAILYARD
ALTERNATIVES IDENTIFICATION AND EVALUATION PROCESS
IDENTIFICATION OF CANDIDATE TECHNOLOGIES

CONTAMINANT OF CONCERN: *VINYL CHLORIDE*

POTENTIALLY AFFECTED MEDIA AND TECHNOLOGIES			APPLICABILITY		
Medium	General Response Action	Candidate Technology	Does This Technology Potentially Apply to Site?	Following the RI Will There Be Sufficient Data to Evaluate in the FS?	COMMENTS
Air	No Action		yes	yes	RI data adequate for evaluation (FSP 3.7; 3.8.3; 6.3.3)
	Monitoring	Monitoring in buildings	yes	yes	RI data adequate for evaluation (FSP 3.7; 3.8.3; 6.3.3)
	Capping	Single barrier: geo-membrane	yes	yes	RI data adequate for evaluation (FSP 3.1; 3.6; 3.7; 3.8.3; 6.3.2; 6.3.3)
		Composite barrier	yes	yes	RI data adequate for evaluation (FSP 3.1; 3.6; 3.7; 3.8.3; 6.3.2; 6.3.3)
	Venting	Passive venting	yes	yes	RI data adequate for evaluation (FSP 3.1; 3.6; 3.7; 3.8.3; 6.3.2; 6.3.3)
		Active venting	yes	yes	RI data adequate for evaluation (FSP 3.1; 3.6; 3.7; 3.8.3; 6.3.2; 6.3.3)
	Treatment	Thermal destruction	yes	yes	RI data adequate for evaluation (FSP 3.7; 3.8.3; 6.3.3)
Groundwater	Monitoring	Monitored natural attenuation	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.8.3; 6.3.1)
		Monitoring flow and contaminant concentration	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.8.3; 6.3.1)
	Containment	Slurry wall	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 3.8.3; 6.3.1; 6.3.2)
		Grout/concrete curtain wall	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 3.8.3; 6.3.1; 6.3.2)
		Sorptive barrier	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 3.8.3; 6.3.1; 6.3.2)
		Sheet-pile wall	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 3.8.3; 6.3.1; 6.3.2)
		Reverse-gradient extraction system.	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 3.8.3; 6.3.1; 6.3.2)
		Hydraulic barrier	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 3.8.3; 6.3.1; 6.3.2)
Groundwater (cont.)	Collection	Extraction wells	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 3.8.3; 6.3.1; 6.3.2)

OGDEN RAILYARD
ALTERNATIVES IDENTIFICATION AND EVALUATION PROCESS
IDENTIFICATION OF CANDIDATE TECHNOLOGIES

CONTAMINANT OF CONCERN: *VINYL CHLORIDE*

POTENTIALLY AFFECTED MEDIA AND TECHNOLOGIES			APPLICABILITY		
Medium	General Response Action	Candidate Technology	Does This Technology Potentially Apply to Site?	Following the RI Will There Be Sufficient Data to Evaluate in the FS?	COMMENTS
		Extraction trench	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 3.8.3; 6.3.1; 6.3.2
	Chemical Treatment	Pretreatment & direct POTW discharge	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.8.3; 6.3.1)
	Biological Treatment	Biodegradation	yes	possibly	There may be value in evaluating the rate of vinyl chloride biodegradation under aerobic conditions
	Physical Treatment	Activated carbon	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.8.3; 6.3.1)
		Reaction wall	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 3.8.3; 6.3.1; 6.3.2
	Disposal	Reinjection	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 3.8.3; 6.3.1; 6.3.2
		Off-site disposal	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.8.1; 6.3.1)

OGDEN RAILYARD
ALTERNATIVES IDENTIFICATION AND EVALUATION PROCESS
IDENTIFICATION OF CANDIDATE TECHNOLOGIES

CONTAMINANT OF CONCERN: *DNAPL HYDROCARBONS*

POTENTIALLY AFFECTED MEDIA AND TECHNOLOGIES			APPLICABILITY		
Medium	General Response Action	Candidate Technology	Does This Technology Potentially Apply to Site?	Following the RI Will There Be Sufficient Data to Evaluate in the FS?	COMMENTS
Air	No Action		yes	yes	RI data adequate for evaluation (FSP 3.7; 6.3.3)
	Monitoring	Monitoring in buildings	yes	yes	RI data adequate for evaluation (FSP 3.7; 6.3.3)
	Capping	Single barrier: geo-membrane	yes	yes	RI data adequate for evaluation (FSP 3.1; 3.6; 3.7; 6.3.2; 6.3.3)
		Composite barrier	yes	yes	RI data adequate for evaluation (FSP 3.1; 3.6; 3.7; 6.3.2; 6.3.3)
	Venting	Passive venting	yes	yes	RI data adequate for evaluation (FSP 3.1; 3.6; 3.7; 6.3.2; 6.3.3)
		Active venting	yes	yes	RI data adequate for evaluation (FSP 3.1; 3.6; 3.7; 6.3.2; 6.3.3)
	Treatment	Thermal destruction	yes	yes	RI data adequate for evaluation (FSP 3.7; 6.3.3)
Soils	Access Restrictions	Excavation restrictions	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
	Capping	Native soil to prevent direct contact	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
	Excavation and Removal	Mechanical excavation	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Consolidation in a designed cell on site	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Remote disposal	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
	Soil Treatment	Air stripping	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Vacuum extraction of contaminants	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Low-temperature thermal volatilization	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Biodegradation	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Vapor extraction	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Off-site treatment	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
Groundwater	Monitoring	Monitored natural attenuation	yes	yes	RI data adequate for evaluation (FSP 3.5; 6.3.1)

OGDEN RAILYARD
ALTERNATIVES IDENTIFICATION AND EVALUATION PROCESS
IDENTIFICATION OF CANDIDATE TECHNOLOGIES

CONTAMINANT OF CONCERN: *DNAPL HYDROCARBONS*

POTENTIALLY AFFECTED MEDIA AND TECHNOLOGIES			APPLICABILITY		
Medium	General Response Action	Candidate Technology	Does This Technology Potentially Apply to Site?	Following the RI Will There Be Sufficient Data to Evaluate in the FS?	COMMENTS
		Monitoring flow and contaminant concentration	yes	yes	RI data adequate for evaluation (FSP 3.5; 6.3.1)
	Access Restrictions	Restrictions on groundwater use	yes	yes	RI data adequate for evaluation (FSP 3.5; 6.3.1)
	Containment	Slurry wall	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Grout/concrete curtain wall	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Sorptive barrier	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Sheet-pile wall	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Reverse-gradient extraction system.	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Hydraulic barrier	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
	Collection	Extraction wells	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Extraction trench	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
	Chemical Treatment	Pretreatment & direct POTW discharge	yes	yes	RI data adequate for evaluation (FSP 3.5; 6.3.1)
	Biological Treatment	Biodegradation	yes	possibly	There may be value in evaluating the rate of DNAPL hydrocarbo biodegradation under aerobic conditions
	Physical Treatment	Activated carbon	yes	yes	RI data adequate for evaluation (FSP 3.5; 6.3.1)
		Reaction wall	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
	Disposal	Reinjection	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Off-site disposal	yes	yes	RI data adequate for evaluation (FSP 3.5; 6.3.1)
<u>Surface Water (21st Street Pond)</u>	Monitoring	Monitored natural attenuation	yes	yes	RI data adequate for evaluation (FSP 3.3; 3.8.1; 6.3.1)
		Contaminant concentration monitoring	yes	yes	RI data adequate for evaluation (FSP 3.3; 3.8.1; 6.3.1)
	Access Restrictions	Fishing prohibition	yes	yes	RI data adequate for evaluation (FSP 3.3; 3.8.1; 6.3.1)
		Fencing	yes	yes	RI data adequate for evaluation (FSP 3.3; 3.8.1; 6.3.1)

OGDEN RAILYARD
ALTERNATIVES IDENTIFICATION AND EVALUATION PROCESS
IDENTIFICATION OF CANDIDATE TECHNOLOGIES

CONTAMINANT OF CONCERN: *DNAPL HYDROCARBONS*

POTENTIALLY AFFECTED MEDIA AND TECHNOLOGIES			APPLICABILITY		
Medium	General Response Action	Candidate Technology	Does This Technology Potentially Apply to Site?	Following the RI Will There Be Sufficient Data to Evaluate in the FS?	COMMENTS
Sludge (21st Street Pond)	Excavation and Removal	Mechanical excavation	yes	yes	RI data adequate for evaluation (FSP 3.4; 3.8.1; 6.3.1)
To be addressed through interim response action		Dewatering	yes	yes	RI data adequate for evaluation (FSP 3.4; 3.8.1; 6.3.1)
		Consolidation in a designed cell on site	yes	yes	RI data adequate for evaluation (FSP 3.4; 3.8.1; 6.3.1)
		Remote disposal	yes	yes	RI data adequate for evaluation (FSP 3.4; 3.8.1; 6.3.1)
	Treatment	Solidification and/or stabilization	yes	yes	RI data adequate for evaluation (FSP 3.4; 3.8.1; 6.3.1)
		On-site incineration	yes	yes.	RI data adequate for evaluation (FSP 3.4; 3.8.1; 6.3.1)
DNAPL	Monitoring	Monitoring flow and contaminant concentration	yes	yes	RI data adequate for evaluation (FSP 3.5; 6.3.1)
	Containment	Slurry wall	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Grout/concrete curtain wall	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Sorptive barrier	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Sheet-pile wall	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Reverse-gradient extraction system.	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
DNAPL (cont.)	Containment (cont.)	Hydraulic barrier	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
	Collection	Mechanical excavation	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Extraction wells	yes	no	Pilot testing will be required
		Extraction trench	yes	no	Pilot testing will be required
	Treatment	Pretreatment & direct POTW discharge	yes	yes	RI data adequate for evaluation (FSP 3.5; 6.3.1)

CONTAMINANT OF CONCERN: *DNAPL HYDROCARBONS*

POTENTIALLY AFFECTED MEDIA AND TECHNOLOGIES			APPLICABILITY		
Medium	General Response Action	Candidate Technology	Does This Technology Potentially Apply to Site?	Following the RI Will There Be Sufficient Data to Evaluate in the FS?	COMMENTS
		In situ chemical oxidation	yes	yes	Sufficient data exists to evaluate these technologies. If the FS identifies this technology as part of the recommended remedy, pilot testing will be required for design.
		Surfactant water flooding	yes	yes	Sufficient data exists to evaluate these technologies. If the FS identifies this technology as part of the recommended remedy, pilot testing will be required for design.
		Steam/hot water floodng	yes	yes	Sufficient data exists to evaluate these technologies. If the FS identifies this technology as part of the recommended remedy, pilot testing will be required for design.
		Off-site treatment	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
	Disposal	Off-site disposal	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)

OGDEN RAILYARD
ALTERNATIVES IDENTIFICATION AND EVALUATION PROCESS
IDENTIFICATION OF CANDIDATE TECHNOLOGIES

CONTAMINANT OF CONCERN: *LOW pH SLUDGE*

POTENTIALLY AFFECTED MEDIA AND TECHNOLOGIES			APPLICABILITY		
Medium	General Response Action	Candidate Technology	Does This Technology Potentially Apply to Site?	Following the RI Will There Be Sufficient Data to Evaluate in the FS?	COMMENTS
Sludge	Access Restrictions	Fencing	yes	yes	RI data adequate for evaluation (FSP 3.8.5; 6.3.1; 6.3.2)
	Capping	Native soil to prevent direct contact	yes	yes	RI data adequate for evaluation (FSP 3.8.5; 6.3.1; 6.3.2)
		Capillary break cap	yes	yes	RI data adequate for evaluation (FSP 3.8.5; 6.3.1; 6.3.2)
		Single barrier: geo-membrane	yes	yes	RI data adequate for evaluation (FSP 3.8.5; 6.3.1; 6.3.2)
		Single barrier: low permeability soil	yes	yes	RI data adequate for evaluation (FSP 3.8.5; 6.3.1; 6.3.2)
		Single barrier: geosyn-thetic clay liner (GCL)	yes	yes	RI data adequate for evaluation (FSP 3.8.5; 6.3.1; 6.3.2)
		Composite barrier	yes	yes	RI data adequate for evaluation (FSP 3.8.5; 6.3.1; 6.3.2)
	Excavation and Removal	Mechanical excavation	yes	yes	RI data adequate for evaluation (FSP 3.8.5; 6.3.1; 6.3.2)
		Consolidation in a designed cell on site	yes	yes	RI data adequate for evaluation (FSP 3.8.5; 6.3.1; 6.3.2)
		Remote disposal	yes	yes	RI data adequate for evaluation (FSP 3.8.5; 6.3.1; 6.3.2)
	Treatment	Solidification and/or stabilization	yes	yes	RI data adequate for evaluation (FSP 3.8.5; 6.3.1; 6.3.2). Treatability testing has previously been performed.
		On-site incineration	yes	yes	RI data adequate for evaluation (FSP 3.8.5; 6.3.1; 6.3.2)
		Composting	yes	yes	RI data adequate for evaluation (FSP 3.8.5; 6.3.1; 6.3.2)
		Land spreading	yes	yes	RI data adequate for evaluation (FSP 3.8.5; 6.3.1; 6.3.2)
		Off-site treatment	yes	yes	RI data adequate for evaluation (FSP 3.8.5; 6.3.1; 6.3.2)

OGDEN RAILYARD
ALTERNATIVES IDENTIFICATION AND EVALUATION PROCESS
IDENTIFICATION OF CANDIDATE TECHNOLOGIES

CONTAMINANT OF CONCERN: *DIESEL*

POTENTIALLY AFFECTED MEDIA AND TECHNOLOGIES			APPLICABILITY		
Medium	General Response Action	Candidate Technology	Does This Technology Potentially Apply to Site?	Following the RI Will There Be Sufficient Data to Evaluate in the FS?	COMMENTS
Air	No Action		yes	yes	RI data adequate for evaluation (FSP 3.7; 6.3.3)
	Monitoring	Monitoring in buildings	yes	yes	RI data adequate for evaluation (FSP 3.7; 6.3.3)
	Capping	Single barrier: geo-membrane	yes	yes	RI data adequate for evaluation (FSP 3.1; 3.6; 3.7; 6.3.2; 6.3.3)
		Composite barrier	yes	yes	RI data adequate for evaluation (FSP 3.1; 3.6; 3.7; 6.3.2; 6.3.3)
	Venting	Passive venting	yes	yes	RI data adequate for evaluation (FSP 3.1; 3.6; 3.7; 6.3.2; 6.3.3)
		Active venting	yes	yes	RI data adequate for evaluation (FSP 3.1; 3.6; 3.7; 6.3.2; 6.3.3)
	Treatment	Thermal destruction	yes	yes	RI data adequate for evaluation (FSP 3.7; 6.3.3)
Soils	Access Restrictions	Excavation restrictions	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
	Capping	Native soil to prevent direct contact	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
	Excavation and Removal	Mechanical excavation	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Consolidation in a designed cell on site	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Remote disposal	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
	Soil Treatment	Air stripping	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Vacuum extraction of contaminants	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		On-site incineration	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Low-temperature thermal volatilization	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Biodegradation	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
Groundwater	Monitoring	Monitored natural attenuation	yes	yes	RI data adequate for evaluation (FSP 3.5; 6.3.1)

OGDEN RAILYARD
ALTERNATIVES IDENTIFICATION AND EVALUATION PROCESS
IDENTIFICATION OF CANDIDATE TECHNOLOGIES

CONTAMINANT OF CONCERN: *DIESEL*

POTENTIALLY AFFECTED MEDIA AND TECHNOLOGIES			APPLICABILITY		
Medium	General Response Action	Candidate Technology	Does This Technology Potentially Apply to Site?	Following the RI Will There Be Sufficient Data to Evaluate in the FS?	COMMENTS
		Monitoring flow and contaminant concentration	yes	yes	RI data adequate for evaluation (FSP 3.5; 6.3.1)
	Containment	Slurry wall	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Grout/concrete curtain wall	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Sorptive barrier	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Sheet-pile wall	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Reverse-gradient extraction system.	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Bottom sealing	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Hydraulic barrier	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
	Collection	Extraction wells	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Extraction trench	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
	Chemical Treatment	Pretreatment & direct POTW discharge	yes	yes	RI data adequate for evaluation (FSP 3.5; 6.3.1)
	Biological Treatment	Biodegradation	yes	possibly	There may be value in evaluating the rate of LNAPL biodegradation under aerobic conditions
	Physical Treatment	Activated carbon	yes	yes	RI data adequate for evaluation (FSP 3.5; 6.3.1)
		Reaction wall	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
	Disposal	Reinjection	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Off-site disposal	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)

OGDEN RAILYARD
ALTERNATIVES IDENTIFICATION AND EVALUATION PROCESS
IDENTIFICATION OF CANDIDATE TECHNOLOGIES

CONTAMINANT OF CONCERN: *DIESEL*

POTENTIALLY AFFECTED MEDIA AND TECHNOLOGIES			APPLICABILITY		
Medium	General Response Action	Candidate Technology	Does This Technology Potentially Apply to Site?	Following the RI Will There Be Sufficient Data to Evaluate in the FS?	COMMENTS
LNAPL	Monitoring	Monitoring flow and contaminant concentration	yes	yes	RI data adequate for evaluation (FSP 3.5; 6.3.1)
	Containment	Slurry wall	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Grout/concrete curtain wall	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Sorptive barrier	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Sheet-pile wall	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Reverse-gradient extraction system.	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Hydraulic barrier	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
	Collection	Extraction wells	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
		Extraction trench	yes	yes	RI data adequate for evaluation (FSP 3.5; 3.6; 6.3.1; 6.3.2)
	Treatment	Pretreatment & direct POTW discharge	yes	yes	RI data adequate for evaluation (FSP 3.5; 6.3.1)
		Off-site treatment	yes	yes	RI data adequate for evaluation (FSP 3.5; 6.3.1)
	Disposal	Off-site disposal	yes	yes	RI data adequate for evaluation (FSP 3.5; 6.3.1)

OGDEN RAILYARD
ALTERNATIVES IDENTIFICATION AND EVALUATION PROCESS
IDENTIFICATION OF CANDIDATE TECHNOLOGIES

CONTAMINANT OF CONCERN: *METALS*

POTENTIALLY AFFECTED MEDIA AND TECHNOLOGIES			APPLICABILITY		
Medium	General Response Action	Candidate Technology	Does This Technology Potentially Apply to Site?	Following the RI Will There Be Sufficient Data to Evaluate in the FS?	COMMENTS
Hot Spots	Access Restrictions	Excavation restrictions	yes	yes	RI data adequate for evaluation (FSP 3.1; 6.3.1)
		Fencing	yes	yes	RI data adequate for evaluation (FSP 3.1; 6.3.1)
	Isolation	Native soil to prevent direct contact	yes	yes	RI data adequate for evaluation (FSP 3.1; 6.3.1)
	Excavation and Removal	Mechanical excavation	yes	yes	RI data adequate for evaluation (FSP 3.1; 6.3.1)
		Consolidation in a designed cell on site	yes	yes	RI data adequate for evaluation (FSP 3.1; 6.3.1)
		Remote disposal	yes	yes	RI data adequate for evaluation (FSP 3.1; 6.3.1)

APPENDIX B
MNA MODELING

MEMORANDUM

THE FORRESTER GROUP

Date: October 29, 2003

To: File

From: Jay Hoskins

Subject: UPRR Ogden Rail Yard
Estimating Cleanup Times Associated with MNA—Part I
Modeling Objectives and Data Requirements

Monitored Natural Attenuation (MNA) is a technology that will be evaluated for groundwater impacted with chlorinated solvents at the Ogden Rail Yard. Consistent with USEPA OSWER Directive 9200.4-17P, alternatives that incorporate MNA will include an estimation of cleanup time.

The software package Natural Attenuation Software (NAS) Version 1.2.2 was developed especially for estimating the time required for MNA to cleanup groundwater. NAS can be used for sites where petroleum hydrocarbons and/or chlorinated solvents are present in groundwater. Details on the development and application of NAS software are available in *Methodology for Estimating Times of Remediation Associated with Monitored Natural Attenuation* (Chapelle et. al, 2003). The NAS Software can be used to estimate the time required for NAPL to dissolve and disperse (i.e., the length of time required for MNA to cleanup groundwater with limited or without any source removal). These types of calculations are called "Time of Remediation" (TOR) calculations.[1]

The purpose of this workplan is to define the objectives of this work and to outline the parameters that will be used in NAS to analyze the northern vinyl chloride plume at the Ogden Railyard.

MODELING OBJECTIVE

Figure 2.1 of the *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater* (USEPA, 1998) outlines the steps that need to be taken in a natural attenuation assessment. The overall objective of the modeling work is to help complete remaining steps needed to navigate through this decision tree. A key question that must be answered in an MNA analysis is "Is it likely that site contaminants are attenuating at rates sufficient to meet remediation objectives for the site in a time period that is reasonable compared to other alternatives?" As discussed in Section 7, the only RAO that MNA does not achieve in a short time period is groundwater restoration. Thus, the specific objective of the modeling work is to develop Time of Remediation ("TOR") estimates for restoring aquifer to MCLs.

DATA REQUIREMENTS

The list of data NAS data requirements includes:

- Hydrogeologic Data.

[1] TOR is defined in NAS as the time required to lower aqueous phase contaminants associated with a NAPL source below a given threshold directly downgradient of the NAPL.

- Contaminant Data.
- Redox Data.
- Source and Remediation Compliance Data/Estimates.

Hydrogeologic Data

NAS allows the user to input degradation rates for a range of hydraulic conductivities, hydraulic gradients, and organic carbon fractions (f_{oc}). For total porosity, effective porosity, and contaminated aquifer thickness, NAS uses an "average or best estimate" value. Table 1 summarizes the hydrogeologic data that will be used in the modeling.

- The range of hydraulic conductivity (28-280 feet/day) and hydraulic gradient values (0.004-0.007 foot/foot) to be used are the same values used to estimate degradation rates in Appendix L of the RI Report.[2]
- f_{oc} values from geotechnical tests performed on site soil ranged from 0.001-0.009 and averaged 0.004 (Table 2).
- Effective and total porosity is assumed to be 0.2. It is reasonable to assume that effective and total porosity are the approximately the same given the porous gravels that compose the alluvial aquifer.
- The alluvial aquifer is impacted throughout the saturated zone; based on hydrographs presented in Appendix A, the average saturated thickness is estimated to be 10.5 feet.

NAS V. 1.2.1 assumes a dispersivity ratio of 1/20 (0.05). While dispersivity at the site may vary from this assumption, the affect of this uncertainty on model output is anticipated to be low compared to other data input (e.g., hydraulic conductivity).

Contaminant Data

NAS calculations are partly based on contaminant concentrations along the plume centerline. In Appendix L of the RI Report, the contaminant data used to derive decay rates was taken from vinyl chloride isoconcentration contour lines at points along the plume centerline. Because NAS examines data for several contaminants at the same point, accurately interpreting multiple contaminant concentrations for these same points along the isoconcentration contour lines is not possible.

Therefore, a modified version of the Appendix L methodology was used. First, the plume centerline between AOI-38 and 35-MW1 was identified from the vinyl chloride isoconcentration contour lines shown in Figures O-1 to O-4 of Part I of the RI Report. Next, monitoring wells lying along the plume

[2] See Appendix L of the RI Report for the rationale used to develop this range.

centerline were identified for each figure. After examining all the figures, it was determined that more monitoring wells fell along the plume centerline in January 2001 than at any other time. Because the plume is steady over the period June 2000-May 2001, data from January 2001 is representative of the plume. Therefore, contaminant data collected in January 2001 will be modeled in NAS.

Seven monitoring wells lie approximately on the plume centerline in January 2001: 38-MW12, 22a-MW6, 34-MW6, 34-MW1, 34-MW7D, and 35-MW1 (Figure 1).[3] Table 2 shows the concentration data from these six monitoring wells. The distance between the wells was taken from the scale shown Figure 1. For the purposes of modeling, it is assumed that 38-MW12 is located at the source.[4]

At Ogden Rail Yard, the vinyl chloride in the groundwater is believed to be the result of two primary decay processes.

- PCE? TCE? 1,2-cis-DCE? Vinyl Chloride.
- 1,1,1-TCA? 1,1-DCE? Vinyl Chloride.[5]

To model these decay processes in NAS, three simplifying assumptions were made.

- Small concentrations of PCE have been detected in groundwater. Vinyl chloride production from PCE is neglected because the relative concentrations of PCE to TCE and 1,1,1-TCA in the northern plume is very low.
- The NAS v 1.2.1 code is not written for modeling the 1,1,1-TCA? 1,1-DCE? Vinyl Chloride degradation chain. If 1,1,1-TCA and 1,1-DCE concentrations are not accounted for at this site, then calculations will underestimate cleanup time. Therefore, the model input uses a "TCE" concentration that is equivalent to the sum of the measured 1,1,1-TCA and TCE concentrations. Similarly, the model input uses a "cis-1,2-DCE" concentration that is equivalent to the sum of the 1,1-DCE and cis-1,2-DCE concentrations.[6]
- Because 1,1,1-TCA and TCE, as well as 1,1-DCE and cis-1,2-DCE, have different sorptive properties, transport calculation results will be different than if the chemicals were individually considered. The effect that this assumption will have on the model's precision is

[3] Because 22a-MW6 and 22-MW6D is a well pair located at the same location, data from 22a-MW6D was not used In general, concentrations at 22a-MW6 were higher than at 22a-MW6D. Therefore, for purposes of estimating cleanup time, data from 22a-MW6 should be more conservative.

[4] The source area is discussed further in "Source and Remediation Compliance Estimates".

[5] See Figure 5-5 of the Ogden RI for a graphical description of the decay chains that form vinyl chloride.

[6] Due to other degradation processes, not all 1,1,1-TCA will form 1,1-DCE and vinyl chloride. Therefore, including the 1,1,1-TCA and 1,1-DCE concentrations helps conservatively predict when biodegradation processes can remediate the aquifer.

anticipated to be relatively small, as indicated by the similar K_{oc} coefficients shown in Table 4.[7]

Redox Indicator Data

The primary purpose for entering the redox data into the NAS system is to analyze the geochemical conditions with the software. Redox indicator data themselves have no effect on TOR estimates, and therefore are not evaluated.

Source and Remediation Compliance Estimates

Limited data is available on source dimensions and composition. Therefore, modeling the source requires that assumptions be made. A sensitivity analysis will be performed on source assumptions to asses the level of certainty in model calculations.

Time of Remediation ("TOR") Calculations

In NAS, the TOR compliance level is the aqueous phase TCE concentration that is to be achieved at the source. At the site, the amount of required source remediation is driven by the ability to achieve the vinyl chloride action level (2 ug/L) in groundwater. Therefore, the compliance concentration needs to reflect the aqueous phase TCE and 1,1,1-TCA concentrations that are equivalent to the vinyl chloride action level. Based on 1 mole of TCE or TCA forming 1 mole of vinyl chloride, the TCE/TCA source removal goal is approximately 4 ug/L.[8]

In NAS, calculations performed to estimate TOR assume that the contaminant source is a DNAPL. DNAPL has not been found at this site, and if it exists, is likely in pockets that defy delineation. None the less, to estimate TOR, it is necessary to develop estimates on the extent and mass of DNAPL that may exist in the aquifer.

TOR calculations in NAS are based on a source area that has a "cubic" configuration. The user is queried about the length (perpendicular to groundwater flow), width (parallel to groundwater flow), and thickness of the NAPL body. Because the exact configuration of a NAPL source is unknown, two source area distributions will be modeled and the output compared.

- 200' (l) x 200' (w) x 0.3' (h). This configuration is intended to represent the source as a "pocket" of DNAPL in AOI-38. 0.3 feet of the saturated thickness is assumed to contain source material.

[7] Within NAS, sorptive properties are fixed values. Therefore a sensitivity analysis on the difference in sorptive properties cannot be performed. However, this conclusion is reasonable when considering the relative similarity in K_{oc} values in comparison to other input parameters, such as groundwater velocity, which may vary by an order of magnitude.

[8] The molecular weights of TCE, TCA, and vinyl chloride are 131.39 g/mol, 133.4 g/mol, and 62.5 g/mol, respectively.

- 999' (l) x 40' (w) x 0.3' (h). The intent of this configuration is to model the source as a "line" of contamination running through the railyard.[9] The volume of the "line" source is approximately equivalent to the volume of the "pocket source" so that the source density (i.e., mass per volume) in both distributions is equivalent.

According to Chapelle et al. (2003), the most important factor in performing TOR calculations is the mass of DNAPL present in the aquifer. DNAPL estimates were made from estimates on the mass of CVOCs sorbed to soil and the mass fraction of CVOCs in groundwater at 38-MW12.

- The mass of CVOCs sorbed to soil is estimated in Table 5. The 5 acre area between 38-MW12 and 22a-MW6 is the most heavily impacted area of north plume groundwater. A total CVOC soil concentration was calculated by generating a geometric average concentration of based on soil data. Geometric average concentrations were generated two ways.

  - Using all soil data (treating samples with non-detected concentrations as has having a concentration equal to ½ the detection limit) collected from the interval 2-18 feet bgs, the geometric average concentration of total CVOCs was calculated to be 0.053 mg/kg. The mass of CVOCs sorbed to soil based on this concentration is estimated to be 20 lbs.

  - Using only soil samples with detected concentrations of CVOCs, the geometric average concentration of total CVOCs was calculated to be 6.8 mg/kg. The mass of CVOCs sorbed to soil based on this concentration is estimated to be 2,500 lbs.

  Based on these calculations, the range of CVOCs sorbed to soil is 20-2,500 lbs. Assuming the actual amount of CVOCs sorbed to soil is somewhere between these two numbers, the mass of CVOCs in soil is conservatively estimated to be about 2,000 lbs. Assuming that the mass of CVOCs in DNAPL and soil are equivalent and that the DNAPL is a 50:50 mixture of chlorinated solvents and petroleum compounds, the "baseline" mass of DNAPL is assumed to be 4,000 lbs.

- The CVOC composition of the DNAPL is estimated in Table 6 and is based on NAPL/groundwater partitioning calculations. Mass fractions were calculated assuming that groundwater concentrations at 38-MW12 are in equilibrium with DNAPL. The mass fraction of CVOCs was then adjusted to 0.5 to reflect a DNAPL mixture that is a 50:50 mixture of chlorinated solvents and petroleum compounds. To account for vinyl chloride formed from 1,1,1-TCA degradation, the mass fraction for TCE will reflect the sum of the TCE and 1,1,1-TCA mass fractions. The cis-1,2-DCE mass fraction used in the model will be the sum of the cis-1,2-DCE and 1,1-DCE mass fractions.

TOR varies almost linearly with respect to NAPL mass for a given degradation rate. Because the mass of the NAPL source at the Ogden Rail Yard is roughly estimated, the precision associated with this calculation is expected to be small. To reflect this, a sensitivity analysis on TOR will be performed for

[9] NAS allows the user to input source dimensions up to 1000 feet.

several DNAPL masses and the results plotted to show TOR vs. DNAPL Mass. While these calculations are not expected to provide exact predictions for TOR, they can be used to provide a baseline for evaluating the efficacy of source removal on reduction in plume length and cleanup times.

The efficacy of source removal on TOR will also be examined for each of the source distributions and contaminant masses. TOR will be calculated for 10, 50, and 90 percent source removal of the estimated 4000 lb source.

REFERENCES

Chapelle, F.H., Widdowson, M.A., Brauner, J.S., Mendez, E., and Casey, C.C. Methodology for Estimating Times of Remediation Associated with Monitored Natural Attenuation. USGS. Columbia, SC. 2003.

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USEPA. Workshop on Monitoring Oxidation-Reduction Processes for Ground-water Restoration. Worshop Summary. Dallas, TX. April 25-27, 2000. EPA/600/R-02/002. January 2002

USEPA. Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater. EPA/600/R-98/128. September 1998.

http://www.cee.vt.edu/nas/ Website for NAS v 1.2.2 software. (Note that the software can be downloaded from this website.)

TABLES

Table 1
Hydrogeologic Data for NAS Modeling
UPRR Ogden Railyard

Parameter	Maximum	Average	Minimum
Hydraulic Conductivity (ft/d)	280	280	28
Hydraulic Gradient (ft/ft)	0.007	0.004	0.004
Fraction of Organic Carbon (%)	0.9%	0.3%	0.1%
Total Porosity		0.2	
Effective Porosity		0.2	
Contaminated Aquifer Thickness (ft)		10.5	

Table 2
Site Geotechnical Data
UPRR Ogden Railyard

Parameter Name	Method	AOI / Units	27 / 27-MW2-4	27 / 27-MW2-8	27 / 27-MW2-10	19 / 19-MW1D-3	19 / 19-MW1D-5	19 / 19-MW1D-8	19 / 19-MW1D-16	19 / 19-MW1D-18	19 / 19-MW1D-24	12 / 12-MW2D-2	12 / 12-MW2D-9	12 / 12-MW2D-13
Moisture	ASTM D 2216	%	9.6	12	7.7	9.3	11.8	15.4	27.3	28.1	26.8	2	2.5	31.4
Grain Size (G,S,F)	ASTM D 422	%	57:40:3	33:64:3	56:37:07	3:56:41	0:60:40	0:75:25	0:11:89	0:6:94	0:19:81	46:44:10	74:23:3	0:5:95
Atterberg Liquid Limit	ASTM D 4318		NP	NP	NP	NP	NP	NP	39	39	NP	NP	NP	40
Atterberg Plastic Limit	ASTM D 4318		NP	NP	NP	NP	NP	NP	17	17	NP	NP	NP	18
Atterberg Plasticity Index	ASTM D 4318		NP	NP	NP	NP	NP	NP	22	22	NP	NP	NP	22
Fraction Organic Carbon	ASA-SSSA		0.001	0.001	0.001	0.007	0.002	0.005	0.003	0.005	0.001	0.009	0.001	0.004

Note:
NP = Nonplastic

Fraction Organic Carbon	
Minimum	**0.001**
Average	**0.003**
Maximum	**0.009**

Table 3
January 2001 Contaminant Data Used in NAS
UPRR Ogden Railyard

Well Name	Downgradient Distance (ft.)	Concentration (ug/L)								
		PCE	TCE	1,1,1-TCA	TCE + TCA	cis-1,2-DCE	1,1-DCE	cis-1,2-DCE + 1,1-DCE	VC	Total CVOCs
38-MW12	0	7	370	2200	2570	3000	170	3170	820	6567
22A-MW6	550	1 U	2	310	312	1500	34	1534	2300	4146
34-MW6	930	1 U	1 U	7	7	93	1	94	1100	1201
34-MW1	1590	1 U	0.6 J	1 U	0.6	6	1 U	6	240	246
34-MW7D	2190	1 U	1 U	1 U	1 U	1 U	1 U	1 U	20	20
35-MW1	2710	1 U	1 U	1 U	1 U	1 U	1 U	1 U	2	2

Table 4
Sorption Parameters for Contaminants at the Ogden Railyard
UPRR Ogden Railyard

Contaminant	VOC (L/kg)	
	Default NAS Value	Literature Value[1]
PCE	364	209 - 238
TCE	126	87 - 150
1,1,1-TCA	NA	183[2]
cis-1,2-DCE	24	49 - 80.2
1,1-DCE	NA	64.6 - 150
Vinyl Chloride	57	0.4 - 56

[1] Taken from Table B.2.1 of Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater, EPA/600/R-98/128, September 1998.
[2] Only one value provided. For all other contaminants, a range of values was provided.
NA Not Available

Table 5
Sorbed CVOC Source Estimate Calculations
UPRR Ogden Rail Yard

Detected Parameter	units	Geometric Average Concentration	
		All Samples	Detects Only
1,1,1-TCA	(mg/kg)	0.012	6.03
1,1-DCA	(mg/kg)	0.017	0.11
cis-1,2-DCE	(mg/kg)	Only one detect	
PCE	(mg/kg)	0.015	0.39
TCE	(mg/kg)	0.0094	0.29
VC	(mg/kg)	Only one detect	
Total VOCs	(mg/kg)	0.053	6.8

Detected Parameter	units	Geometric Average Mass	
		All Samples	Detects Only
1,1,1-TCA	lbs	4	2,223
1,1-DCA	lbs	6	39
cis-1,2-DCE	lbs	Not Calculated	
PCE	lbs	5	143
TCE	lbs	3	106
VC	lbs	Not Calculated	
Total VOCs	lbs	20	2,500

Notes
Assumed soil density of 94 lbs/cf (1.5 g/cc)
Assumed volume of 5 acres over 18 feet deep (or 7.06E6 cf)
Soil sample locations included in average calculations were 22a-B4, 22a-MW6/6D, 38-B11P, -B12P, -B1P, -B2, -B3P, -B5, and -MW12

Table 6
Sorbed VOCs: Source Estimate Calculations
UPRR Ogden Railyard

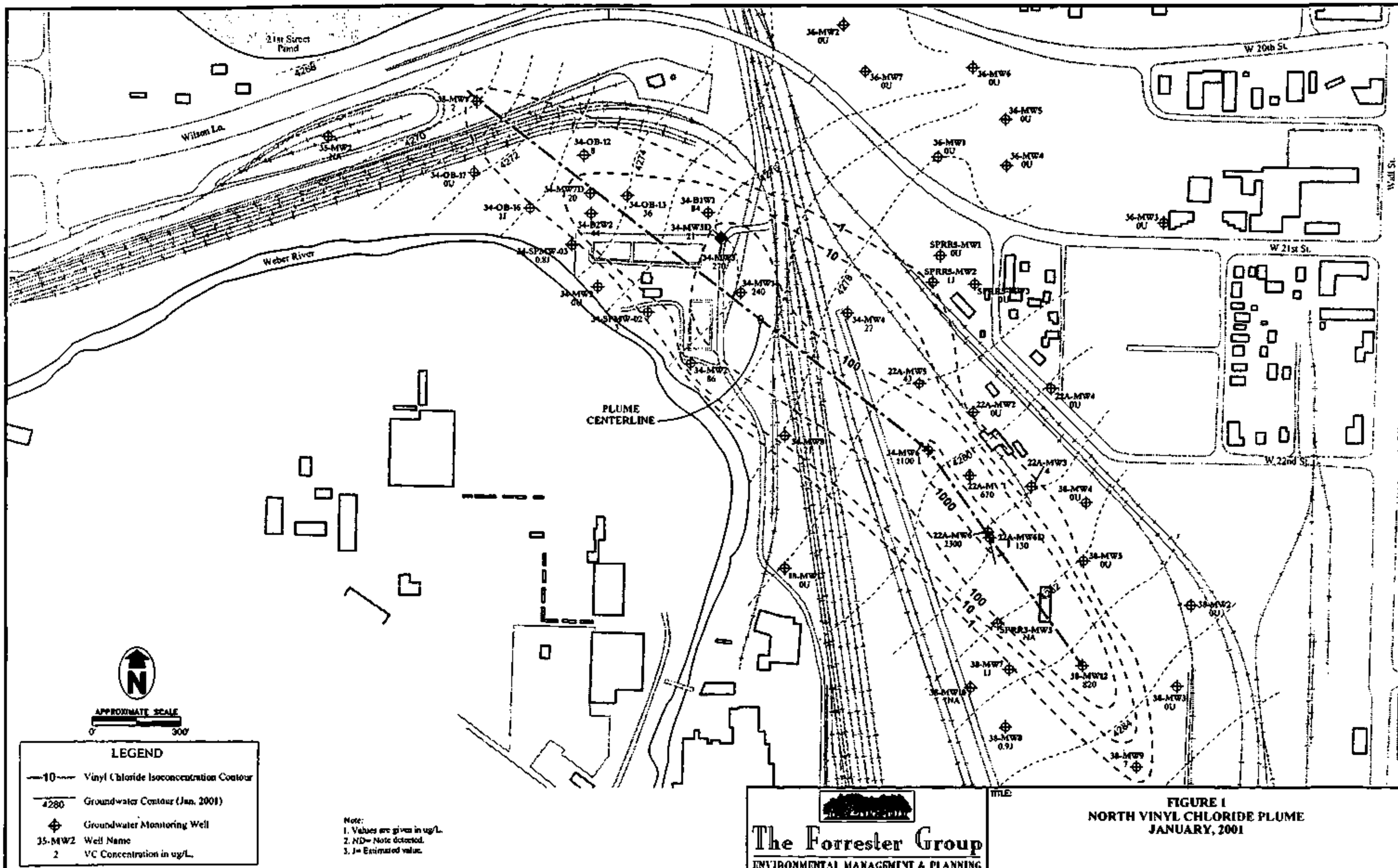
	Groundwater Concentration	Aqueous Solubility[a]	Mass Fraction	
Units	(ug/L)	(mg/L)		
Constituent	38-MW12	38-MW12	Unadjusted[b]	Adjusted[c]
PCE	7	1503	4.66E-06	7.67E-04
TCE	370	1100	3.36E-04	0.06
1,1,1-TCA	2200	1495	1.47E-03	0.24
cis-1,2-DCE	3000	3500	8.57E-04	0.14
1,1-DCE	170	2500	6.80E-05	0.01
VC	820	2763	2.97E-04	0.05
Total CVOCs	6567	--	3.03E-03	0.5
TCE+1,1,1-TCA	2570	--	1.81E-03	0.30
cis-1,2-DCE+1,1-DCE	3170	--	9.25E-04	0.15

a Aqueous solubility values taken from Table B.2.1 of the EPA Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater

b Groundwater concentrations at 38-MW12 are assumed to be in equilibrium with DNAPL. It is assumed that Mass fraction = Groundwater Concentration/Solubilty

c Mass fractions are adjusted to reflect that total CVOCs make up 50 percent of the DNAPL

FIGURES



21st Street Pond
Wilson Ln.
Weber River
W 20th St.
W 21st St.
W 22nd St.
Wall St.
PLUME CENTERLINE
N
APPROXIMATE SCALE
0' 300'
LEGEND
10 Vinyl Chloride Isoconcentration Contour
4280 Groundwater Contour (Jan. 2001)
Groundwater Monitoring Well
35-MW2 Well Name
2 VC Concentration in ug/L.
Note:
1. Values are given in ug/L.
2. ND= Note detected.
3. J= Estimated value.
The Forrester Group
ENVIRONMENTAL MANAGEMENT & PLANNING
TITLE:
FIGURE 1
NORTH VINYL CHLORIDE PLUME
JANUARY, 2001

APPENDIX A
NORTH PLUME HYDROGRAPH DATA

Table A-1
North Plume Water Level and Saturated Thickness Data
UPRR Ogden Railyard

	22A-MW5[1]		22A-MW1[1]		22A-MW6[1]		22A-MW6D[2]	
Elevation of Clay	4270		4270		4267		4267	
Ground Elevation	4289.3		4290.47		4290.36		4290.41	
Depth to Clay	19		20		23		23	
Date	Water Level (ft. MSL)	Saturated Zone Thickness (ft.)	Water Level (ft. MSL)	Saturated Zone Thickness (ft.)	Water Level (ft. MSL)	Saturated Zone Thickness (ft.)	Water Level (ft. MSL)	Saturated Zone Thickness (ft.)
Mar-00	NA	NA	4282.00	12	NA	NA	NA	NA
Apr-00	NA	NA	4281.79	12	NA	NA	NA	NA
May-00	NA	NA	4281.38	11	NA	NA	NA	NA
Jun-00	NA	NA	4280.73	11	4281.46	14	4281.46	14
Jul-00	4279.15	9	4280.40	10	4281.05	14	4281.05	14
Aug-00	4278.92	9	4280.10	10	4280.80	14	4280.80	14
Sep-00	4279.26	9	4280.44	10	4281.16	14	4281.16	14
Oct-00	4279.02	9	4280.15	10	4280.85	14	4280.85	14
Nov-00	4279.33	9	4280.50	11	4281.24	14	4281.24	14
Dec-00	4279.17	9	4280.29	10	4280.96	14	4280.96	14
Jan-01	NA	NA	4280.29	10	4281.01	14	4281.01	14
Feb-01	4279.64	10	4280.69	11	4281.56	15	4281.56	15
Mar-01	4279.93	10	4281.09	11	4281.61	15	4281.61	15
Apr-01	4280.69	11	4292.65	23	4282.72	16	4282.72	16
May-01	4280.60	11	4281.79	12	4282.54	16	4282.54	16
Jun-01	4279.49	9	4280.65	11	4281.48	14	4281.48	14
Jul-01	4279.11	9	4280.29	10	4281.08	14	4281.08	14
Aug-01	4278.86	9	4280.00	10	4280.75	14	4280.75	14
Sep-01	4278.65	9	4279.76	10	4280.52	14	4280.52	14
Oct-01	4278.75	9	4279.83	10	4280.54	14	4280.54	14
Low	4278.65	9	4279.76	10	4280.52	14	4280.52	14
High	4280.69	11	4292.65	23	4282.72	16	4282.72	16
Average	4279.37	9	4281.24	11	4281.25	14	4281.25	14

Notes:
NA--Data not available
[1] Depth to clay estimated based on RI Report Figure 3-8
[2] Depth to clay taken from boring

Table A-2
North Plume Water Level and Saturated Thickness Data
UPRR Ogden Railyard

	34-B1W1[1]		34-MW3D[2]		34-MW3[1]		34-MW1[1]		34-MW4[1]		34-MW6[1]	
Elevation of Clay	4261		4261		4261		4261		4268		4270	
Ground Elevation	4284.28		4285.97		4286.26		4286.24		4289.19		4283.69	
Depth to Clay	23		25		25		25		21		14	
Date	Water Level (ft. MSL)	Saturated Zone Thickness (ft.)	Water Level (ft. MSL)	Saturated Zone Thickness (ft.)	Water Level (ft. MSL)	Saturated Zone Thickness (ft.)	Water Level (ft. MSL)	Saturated Zone Thickness (ft.)	Water Level (ft. MSL)	Saturated Zone Thickness (ft.)	Water Level (ft. MSL)	Saturated Zone Thickness (ft.)
Mar-00	4276.99	16	4277.10	16	4277.17	16	4277.44	16	4279.87	12	4281.48	11
Apr-00	4276.85	16	4277.11	16	4277.11	16	4277.28	16	4279.60	12	4281.31	11
May-00	4276.49	15	4276.78	16	4276.76	16	4276.91	16	4279.25	11	4280.92	11
Jun-00	4275.98	15	4276.22	15	4276.20	15	4276.34	15	4278.59	11	4280.22	10
Jul-00	4275.82	15	4276.05	15	4276.06	15	4276.15	15	4278.31	10	4279.82	10
Aug-00	4275.56	15	4275.80	15	4275.78	15	4275.92	15	4278.04	10	4279.65	10
Sep-00	4275.93	15	4276.18	15	4276.16	15	4276.28	15	4278.41	10	NA	NA
Oct-00	4275.70	15	4275.95	15	4275.94	15	4276.07	15	4278.18	10	NA	NA
Nov-00	4275.91	15	4276.17	15	4276.13	15	4276.26	15	4278.49	10	NA	NA
Dec-00	4275.85	15	4276.08	15	4276.06	15	4276.18	15	4278.32	10	4279.84	10
Jan-01	4275.81	15	4276.00	15	4275.95	15	4276.09	15	4278.35	10	4279.76	10
Feb-01	4276.10	15	4276.35	15	4276.37	15	4276.49	15	4278.82	11	4280.15	10
Mar-01	4276.29	15	4276.57	16	4276.57	16	NA	NA	4279.00	11	4280.74	11
Apr-01	4276.89	16	4277.17	16	4277.44	16	4277.23	16	4279.67	12	4281.39	11
May-01	4276.87	16	4277.12	16	4277.18	16	4276.86	16	4279.57	12	4281.38	11
Jun-01	4276.10	15	4276.39	15	4276.35	15	4276.37	15	4278.55	11	4280.22	10
Jul-01	4275.74	15	4276.02	15	4276.00	15	4276.03	15	4278.17	10	4279.85	10
Aug-01	4275.54	15	4275.80	15	4275.78	15	4275.80	15	4277.95	10	4279.60	10
Sep-01	4275.50	15	4275.54	15	4275.53	15	4275.53	15	4277.67	10	4279.35	9
Oct-01	4275.52	15	4275.74	15	4275.70	15	4275.81	15	4277.87	10	4279.37	9
Low	4275.50	15	4275.54	15	4275.53	15	4275.53	15	4277.67	10	4279.35	9
High	4276.99	16	4277.17	16	4277.44	16	4277.44	16	4279.87	12	4281.48	11
Average	4276.07	15	4276.31	15	4276.31	15	4276.37	15	4278.64	11	4280.30	10

Notes:
NA--Data not available
[1] Depth to clay estimated based on RI Report Figure 3-8
[2] Depth to clay taken from boring

Table A-3
North Plume Water Level and Saturated Thickness Data
UPRR Ogden Railyard

	38-B3P[1]		38-B11P[1]		38-MW6[1]		38-B28P[1]		38-MW5[1]		38-MW12[1]		SPRR3-MW3[1]	
Elevation of Clay	4275		4275		4275		4272		4275		4273		4267	
Ground Elevation	4290.7		4290.71		4290.93		NA		4291.08		4290.85		4291.29	
Depth to Clay	16		16		16		NA		16		18		24	
Date	**Water Level (ft. MSL)**	**Saturated Zone Thickness (ft.)**	**Water Level (ft. MSL)**	**Saturated Zone Thickness (ft.)**	**Water Level (ft. MSL)**	**Saturated Zone Thickness (ft.)**	**Water Level (ft. MSL)**	**Saturated Zone Thickness (ft.)**	**Water Level (ft. MSL)**	**Saturated Zone Thickness (ft.)**	**Water Level (ft. MSL)**	**Saturated Zone Thickness (ft.)**	**Water Level (ft. MSL)**	**Saturated Zone Thickness (ft.)**
Mar-00	4285.68	11	4285.78	11	4285.59	11	NA	NA	4283.91	9	NA	NA	4283.20	16
Apr-00	4285.20	10	4285.20	10	4284.75	10	4284.29	12	4283.46	8	NA	NA	4282.93	16
May-00	4284.73	10	4284.74	10	4283.33	8	4283.78	12	4282.98	8	NA	NA	4282.49	15
Jun-00	4284.26	9	4284.27	9	4283.79	9	4283.21	11	4282.42	7	4283.92	11	4281.86	15
Jul-00	4283.91	9	4283.75	9	4283.41	8	4282.83	11	4281.97	7	4283.53	11	4281.47	14
Aug-00	4283.62	9	4283.62	9	4283.16	8	4283.56	12	4281.73	7	4283.25	10	4281.21	14
Sep-00	4283.88	9	4283.90	9	4283.45	8	4282.92	11	4282.19	7	4283.55	11	4281.56	15
Oct-00	4283.53	9	4283.54	9	4283.10	8	4282.53	11	4281.82	7	4283.19	10	4281.29	14
Nov-00	4283.95	9	4283.93	9	4283.48	8	4282.95	11	4282.28	7	4283.56	11	4281.61	15
Dec-00	4283.62	9	4283.63	9	4283.13	8	4282.60	11	4281.99	7	4283.24	10	4281.39	14
Jan-01	4283.53	9	4283.60	9	4283.16	8	4282.52	11	4282.06	7	NA	NA	4281.27	14
Feb-01	4283.99	9	4283.38	8	4283.59	9	NA	NA	4282.72	8	4283.77	11	4281.66	15
Mar-01	4284.44	9	4284.41	9	4283.98	9	4283.48	11	4282.86	8	4283.10	10	4282.23	15
Apr-01	4285.19	10	4285.21	10	4284.75	10	4284.38	12	4283.76	9	4284.98	12	4283.06	16
May-01	4284.81	10	4284.80	10	4284.35	9	4283.89	12	4283.44	8	4284.73	12	4282.61	16
Jun-01	4284.25	9	4284.21	9	4283.77	9	4283.23	11	4282.61	8	4283.88	11	4281.75	15
Jul-01	4284.19	9	4284.28	9	4283.44	8	4282.84	11	4282.20	7	4283.53	11	4281.47	14
Aug-01	4283.84	9	4283.92	9	4283.11	8	4282.51	11	4281.83	7	4284.40	11	4281.19	14
Sep-01	4283.58	9	4283.74	9	4282.81	8	4282.16	10	4281.56	7	4282.68	10	4280.95	14
Oct-01	4283.39	8	4283.50	8	4282.76	8	4282.09	10	4281.53	7	4282.36	9	NA	NA
Low	4283.39	8	4283.38	8	4282.76	8	4282.09	10	4281.53	7	4282.36	9	4280.95	14
High	4285.68	11	4285.78	11	4285.59	11	4284.38	12	4283.91	9	4284.98	12	4283.20	16
Average	4284.18	9	4284.17	9	4283.65	9	4283.10	11	4282.46	7	4283.61	11	4281.85	15

Notes:
NA--Data not available
[1] Depth to clay estimated based on RI Report Figure 3-8
[2] Depth to clay taken from boring

MEMORANDUM

THE FORRESTER GROUP
INSIGHTFUL ENVIRONMENTAL SOLUTIONS

Date: October 30, 2003

To: File

From: Jay Hoskins

Subject: UPRR Ogden Rail Yard
Estimating Cleanup Times Associated with MNA—Part II
Natural Attenuation Modeling Results

This memo provides the results of natural attenuation time of remediation (TOR) modeling that was performed for the Ogden Rail Yard Feasibility Study. Inherent to this modeling are simplifying assumptions, and therefore calculations are most appropriately employed as a qualitative tool for screening options and projecting trends in groundwater quality over time. This analysis is not intended as a definitive projection of future groundwater concentrations.

In developing cleanup time estimates, a sensitivity analysis was performed to examine:

- Variability in source mass on TOR.
- Variability of groundwater velocity on TOR.
- Variability of source configuration on TOR.
- Effects of source removal on aqueous source concentrations in the short-term.

Variability in Source Mass on TOR

Cleanup times were calculated for several source masses to estimate the relationship between source mass and cleanup time for the site. Charts 1 and 2 show Source Mass vs. Time of Remediation for the two source configurations and two groundwater velocities that were modeled. Results indicate that for both source configurations, cleanup time increases with source mass in a linearly relationship. The model results indicate that a 4,000 lb mass of DNAPL in a "pocket" configuration could take from 6-60 years to reach cleanup levels. Cleanup times for a 4,000 lb mass of DNAPL in a "line" source are calculated to be 9-90 years.

Removing contaminant source decreases the amount of time required by natural attenuation processes to achieve aqueous phase criteria. However, because the amount and composition of the DNAPL is uncertain, it is impossible to accurately quantify what affect source removal would have on decreasing TOR.

Variability in Groundwater Velocity on TOR

The inputs for groundwater velocity (i.e., hydraulic conductivity, hydraulic gradient, and effective porosity) affect calculations estimating degradation rates and advective transport. As groundwater velocity increases for a given plume size, the calculated rate of biodegradation also increases. And, if contaminants are carried away from the source faster, then the source is depleted faster.

The potential variability in groundwater velocity was examined by varying hydraulic conductivity by one-order of magnitude. For a 4000 lb "pocket source", TOR was calculated to be 6 and 61 years for velocities of 5.6 and 0.56 feet/day. For a 4000 lb "line source", TOR was calculated to be 9 and 90 years for velocities of 5.6 and 0.56 feet/day. Based on these calculations, for an order of magnitude change in groundwater velocity, there is an equivalent change in cleanup time. If the actual hydraulic conductivity at the site varies up to an order of magnitude of the measured value (as was proposed in the RI Report), then the potential variability in groundwater velocity adds significant uncertainty to estimating the time required to restore the site.

Effect of Source Configuration on TOR

The effect of source configuration on TOR was examined by developing a chart of concentration vs. time for the "pocket" and "line" sources (Chart 3). TOR was greater for the "line" source than a "pocket" source configuration. These results imply that removing a portion of the source running parallel to the groundwater flow direction has a greater effect on reducing cleanup times that removing an equal amount of "pocket" source.

The sewer line running between AOI-38 and AOI-34 has been proposed as a potential source of groundwater contamination. Recognizing that model calculations do not precisely represent the impacts from this sewer line (e.g., the sewer line is above the groundwater table and the groundwater impacts are result of rainwater infiltration through the sewer line and into the groundwater, etc.), one can still infer from the results that removing this source would help achieve groundwater restoration. However, as indicated in Chart 3, there is a great deal of uncertainty on the magnitude of this effect.

Effects of Source Removal on Aqueous Source Concentrations in the Near-Term

Groundwater monitoring indicates that concentrations of CVOCs in the Northern Plume are not increasing and have reached steady-state levels. Over time, as the source is further depleted, it is anticipated that concentrations will drop. (Recent sampling suggests this may already be occurring.) One question is then would additional source removal advance achievement of water quality objectives in the near term?

To answer this question, the concentration vs. time plots in Charts 4 and 5 were developed for 10, 50, and 90 percent removal of a 4,000 lb mass. The maximum CVOC concentration, which occurs in the near-term (i.e., less than a year) for each removal scenario, was determined from Charts 4 and 5. Table 1 compares the percentage of source removed to the percentage decrease in aqueous phase CVOC concentration. As shown in Table 1, the reduction in source mass results in less than a 1:1 reduction in aqueous phase concentration. Even a 90 percent removal in source mass only reduces near term source concentrations by 67 percent. Therefore, it is concluded that partial source removal does little to improve near-term groundwater.

The limited near-term benefits to improved groundwater quality resulting from source zone removal have also been demonstrated in literature. For example, Tom Sale's doctoral dissertation (1998) quantitatively documents this effect and then concluded, "Meaningful improvement in near-term groundwater quality via remediation will require nearly complete removal of DNAPL."

Conclusions

- The length of time required to cleanup groundwater varies linearly with source mass. Larger source masses require a longer remediation time that smaller ones.

- Removing the sources of CVOCs decreases the amount of time required by natural attenuation processes to achieve aqueous phase criteria. However, because the total amount of source is difficult to quantify, the effect of source removal is uncertain. Calculations indicate that the remediation time could be a decade, but this estimate is very uncertain because the total mass of CVOCs is very uncertain.

- Partial source removal improves the time required to restore the aquifer in the long-term, however partial source removal does little to improve near-term groundwater quality. Virtually all source material would need to be removed before meaningful improvements in near-term groundwater quality are achieved.

Chart 1
Source Mass vs. TOR for 200' x 200' Pocket Source
v=5.6 and 0.56 feet/day
9/27/2004

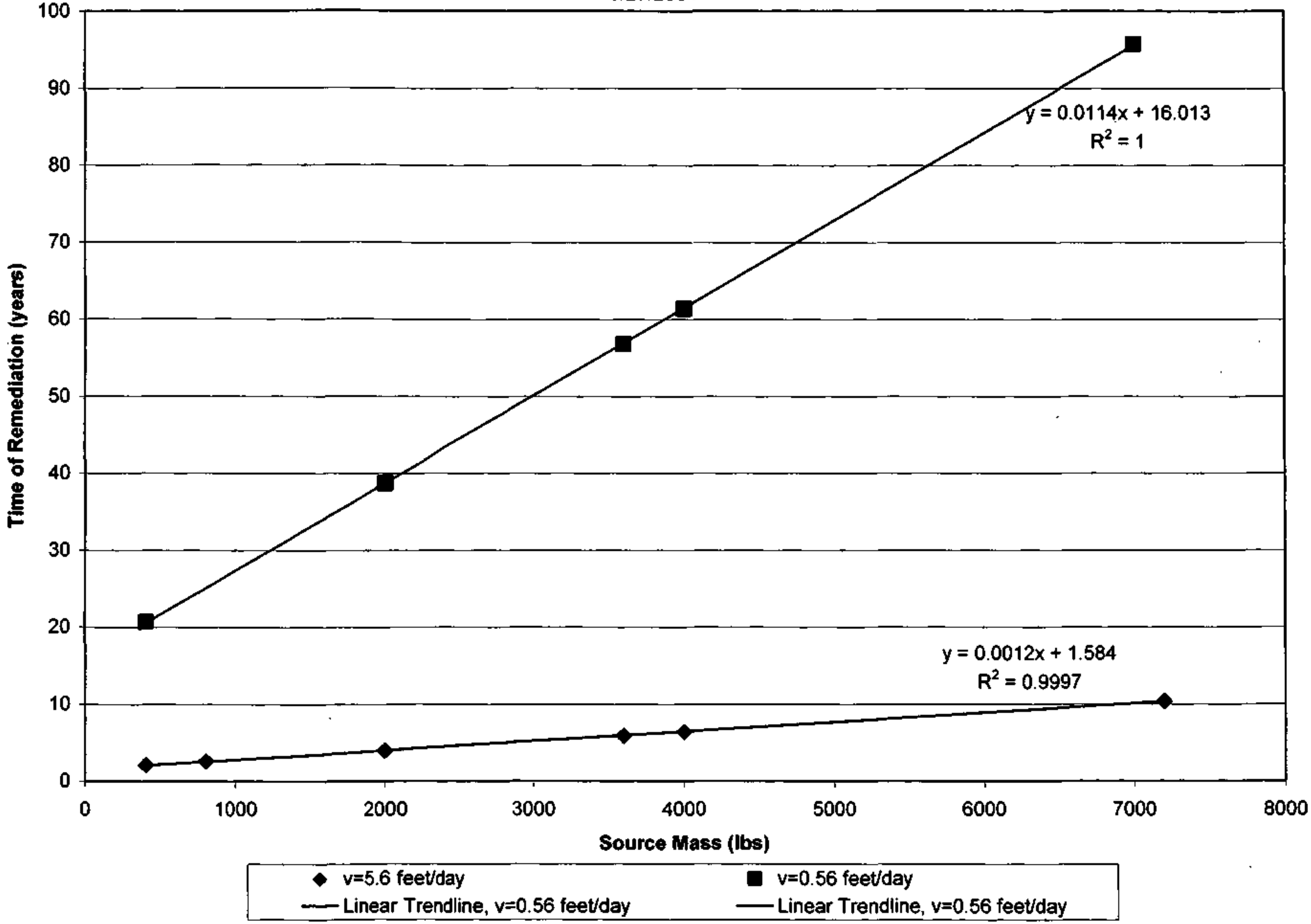


Chart 2
Source Mass vs. TOR for 999' x 40' Line Source
v=5.6 and 0.56 feet/day
9/27/2004

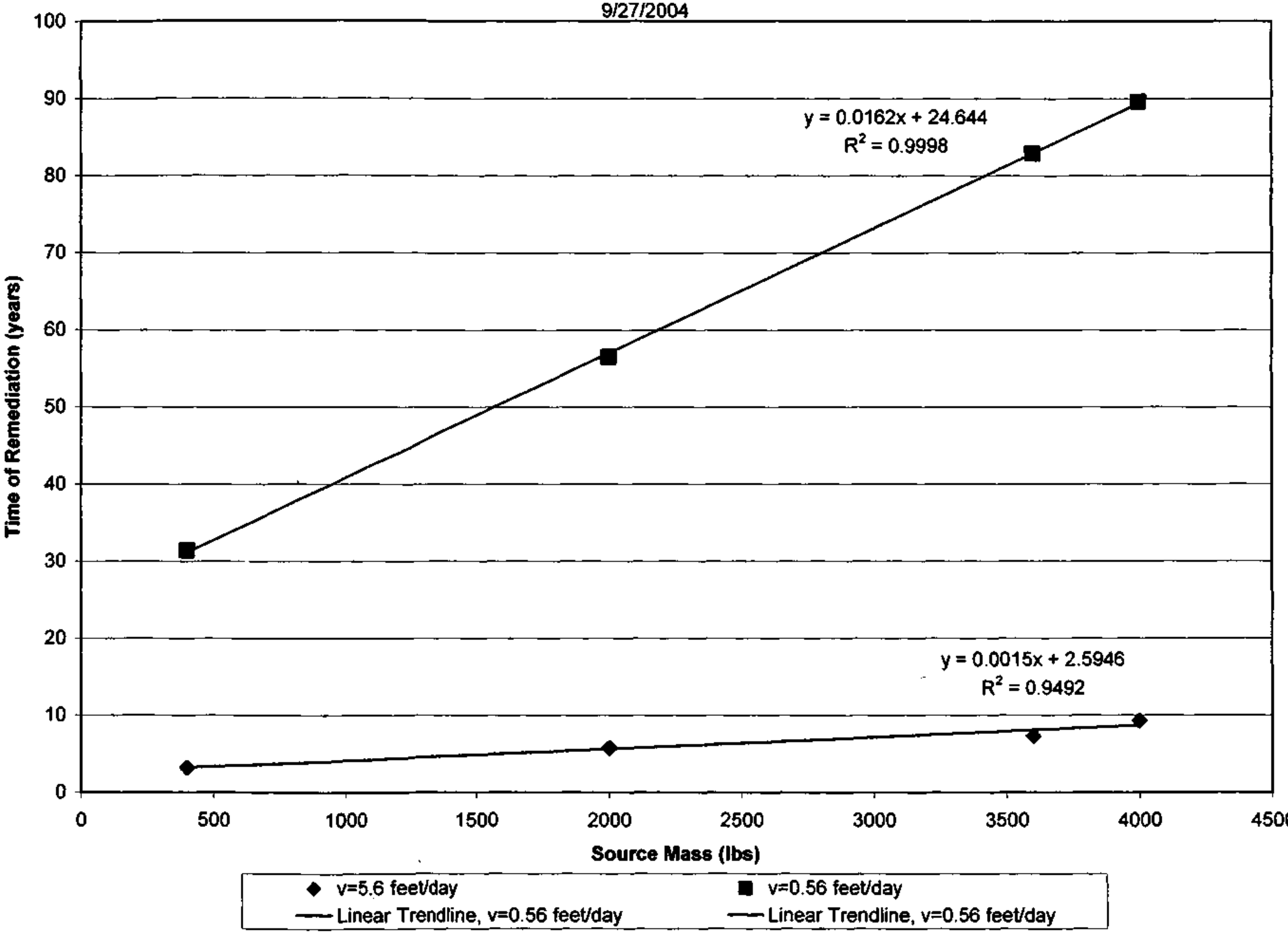


Chart 3
Aqueous Concentration of Parent CVOCs over Time
Comparison of Source Area Scenarios
9/27/2004

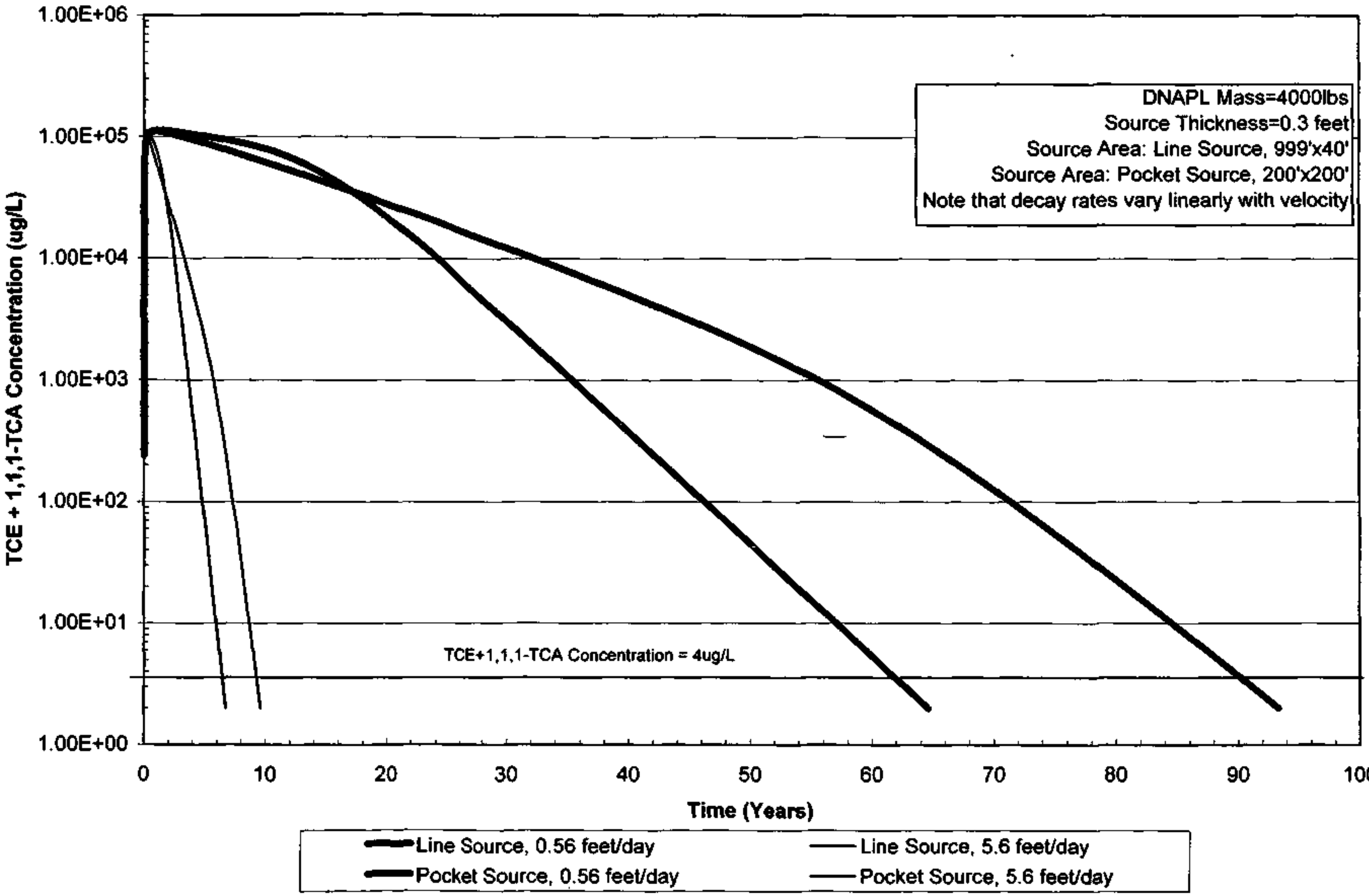


Chart 4
Aqueous Source Concentrations over Time
Source Area 999' x 40'
9/27/2004

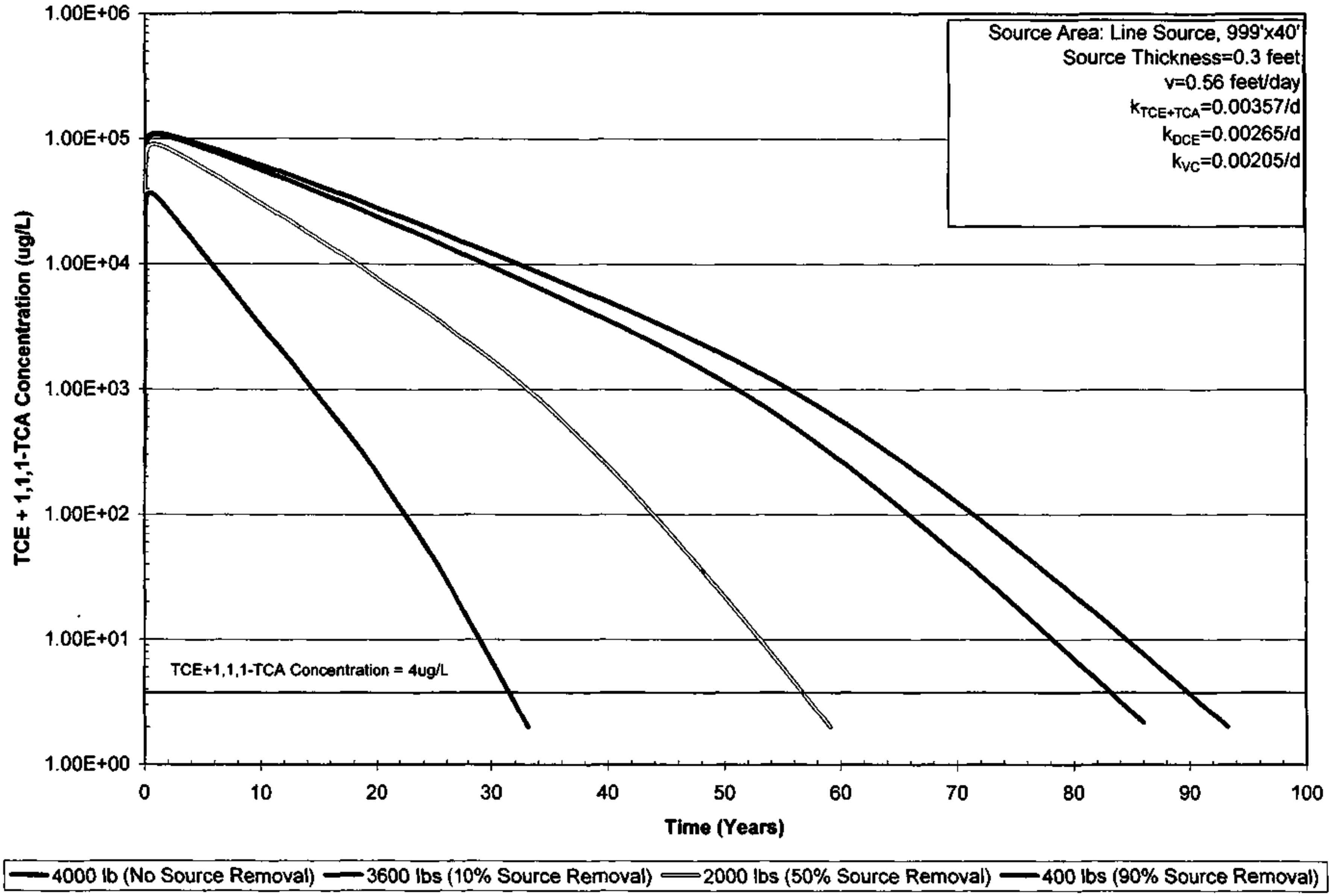


Chart 5
Aqueous Source Concentrations over Time
Source Area: 200' x 200'
9/27/2004

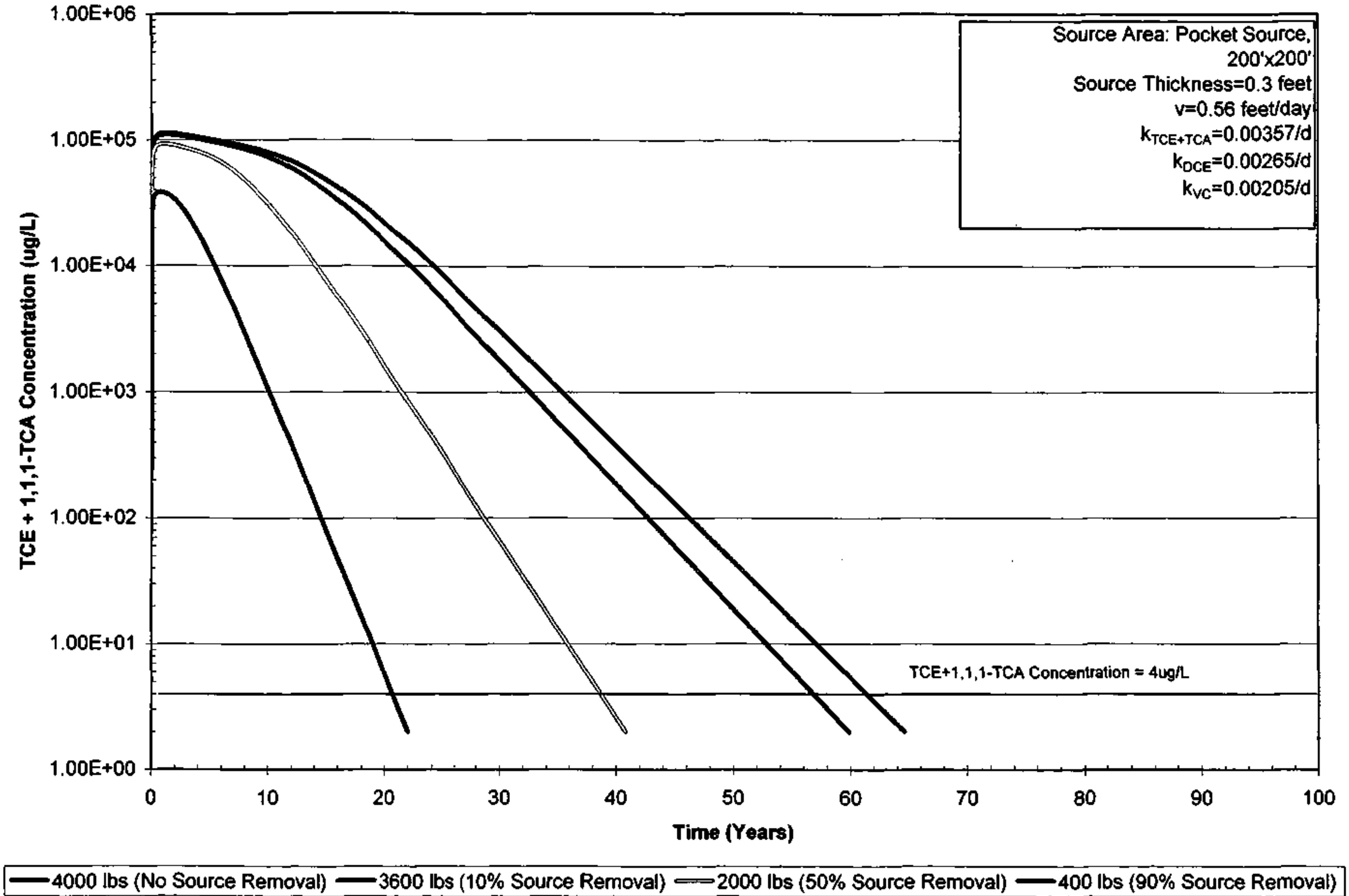


Table 1
Affects of Source Removal on Aqueous Phase Concentrations
UPRR Ogden Rail Yard
10/30/2003

Source Mass	Percent Mass Removal	Pocket Source: 200'(w)x200'(w)		Line Source: 40'(w)x999'(l)	
		Aqueous Concentration (Max) at Source (ug/L)	Percent Reduction in Aqueous Phase Concentration	Aqueous Concentration (Max) at Source (ug/L)	Percent Reduction in Aqueous Phase Concentration
Lbs	--				
4000	0%	113,170	0%	111,010	0%
3600	10%	110,450	2%	108,260	2%
2000	50%	92,978	18%	90,667	18%
400	90%	38,433	66%	36,884	67%

APPENDIX C
SUMMARY OF AOI-38 AND INDUSTRIAL SEWER LINE INVESTIGATIONS

MEMORANDUM

THE FORRESTER GROUP
INSIGHTFUL ENVIRONMENTAL SOLUTIONS™

Date: April 16, 2004

To: Eva Hoffman, EPA
Michael Storck, UDEQ

From: Hoyt Sutphin, Tom Sale, Jay Hoskins

Subject: AOI-38, subsurface VOC soil concentrations, Ogden, Utah

Copy to: Gary Honeyman, UPRR
Keith Piontek, TFG
Julia Fowler, K/J

Overview

The following provides a brief review and interpretation of AOI-38 and AOI-22a sampling results, from soil samples collected to evaluate the existence of an additional contaminant source for the northern CVOC groundwater plume. In summary, it appears that minor residual CVOC contamination may exist at two of eleven locations investigated.

Building on this, options for site remedy selection are reviewed. From the review it appears that the most prudent action, consistent with Remedial Alternative 3, is to 1) continue to allow active biological process to continue degrade the apparent residual contamination, and 2) conduct the appropriate monitoring to demonstrate the adequacy of this approach. The principle concern with active intervention (e.g. In-situ Chemical Oxidation) is that these actions could deplete (or destroy) anaerobes that are currently mediating contaminant degradation. Active intervention could inhibit the observed biological attenuation documented to be occurring, and adversely affect future migration of CVOCs in groundwater.

Field Data

A direct push investigation was performed in AOI-38 and AOI-22a on March 4-8, 2004. The objective of the investigation was to further resolve the potential existence of a subsurface source of chlorinated volatile organic compounds (CVOCs) beneath areas of greatest likely occurrence (shops, pits, and drains). Eleven borings were completed to the top of the Alpine Clay (approximately 15-20 feet deep). Discrete soil samples were collected at these locations from the Alluvium immediately above the Alpine Clay[1]. Samples were then analyzed for chlorinated volatile organic compounds ("CVOCs") by SW-846 Method 8260. Soil boring locations are shown in Figure 1. Preliminary analytical results are presented in Table 1 (non-validated data).

[1] Samples were not collected at 38-B37 and 38-B39 because the target depth could not be achieved during drilling. Borings B-38 and B-40 (which were sampled) were installed immediately adjacent to these locations.

605 North Boonville Avenue, Springfield, MO 65806, p 417.864.6444, f 417.864.6445
500 Chesterfield Center, Suite 300, Chesterfield, MO 63017, p 636.728.1034, f 636.728.1035
14 Corporate Woods, Suite 650, 8717 West 110th Street, Overland Park, KS 66210, p 913.469.0688, f 913.469.0686
812 Swifts Highway, Jefferson City, MO 65109, p 573.634.8109, f 573.634.8224
5460 Ward Road, Suite 110, Arvada, Colorado 80002, p 303.456.0400, f 303.456.0232
136 East South Temple, Suite 1820, Salt Lake City, Utah 84111, p 801.355.3721, f 801.355.3791

www.forrestergroup.com

Table 1 – Concentrations of SVOCs in Gravel Immediately Above the Alpine Formation

Sample ID	Analysis	Result	Reporting Limit	Unit
22A-B24	cis-1,2-Dichloroethene	10	5	ug/Kg
38-B41	1,1-Dichloroethane	170	50	ug/Kg
38-B41	1,1-Dichloroethene	96	50	ug/Kg
38-B41	1,2-Dichloroethene (total)	1700	100	ug/Kg
38-B41	cis-1,2-Dichloroethene	1700	50	ug/Kg
38-B41	Ethylbenzene	180	50	ug/Kg
38-B41	Tetrachloroethene	130,000	3000	ug/Kg
38-B41	Toluene	67	50	ug/Kg
38-B41	1,1,1-Trichloroethane	2900 J	600	ug/Kg
38-B416	Trichloroethene	2900 J	600	ug/Kg
38-B41	Xylenes (total)	740	150	ug/Kg
38-B42	cis-1,2-Dichloroethene	6	5	ug/Kg
38-B43	cis-1,2-Dichloroethene	6	5	ug/Kg
38-B44	1,1-Dichloroethane	740	50	ug/Kg
38-B44	1,1-Dichloroethene	130	5	ug/Kg
38-B44	1,2-Dichloroethene (total)	22,000	6000	ug/Kg
38-B44	cis-1,2-Dichloroethene	22,000	3000	ug/Kg
38-B44	trans-1,2-Dichloroethene	11	5	ug/Kg
38-B44	Ethylbenzene	29	5	ug/Kg
38-B44	Tetrachloroethene	27,000	3000	ug/Kg
38-B44	Toluene	210	5	ug/Kg
38-B44	1,1,1-Trichloroethane	9200	3000	ug/Kg
38-B44	Trichloroethene	1200	50	ug/Kg
38-B44	Vinyl Chloride	520	100	ug/Kg
38-B44	Xylenes (total)	150	15	ug/Kg
22a-B23	1,1-Dichloroethane	6	5	ug/Kg
38-B46	1,1-Dichloroethane	6	5	ug/Kg
38-B45	all ND			
38-B47	all ND			
38-B38	all ND			
38-B40	all ND			

Data Interpretation

The observed contaminants include:

- Chlorinated solvents commonly used as degreasers (TCE, PCE, and 111-TCA)
- Petroleum hydrocarbons (Benzene and Toluene)
- Daughter products (DCE and VC) associated with biological degradation of the PCE, TCE, and TCA

A plausible scenario is that minor releases of waste solvents, containing petroleum hydrocarbons, may have occurred in the vicinity of AOI-38. The most likely place for these materials to have accumulated is at the alluvial Alpine Clay contact where the soil samples were collected.

The first step taken in interpreting the data was to resolve the soil concentration that would indicate the presence of DNAPL. Following Simpkin et al., 2000, this can be estimated as the maximum amount of contamination that can occur due to dissolved (water) and sorbed contaminant phases (See Attachment A). As shown in Table 2 below, the maximum TCE and PCE concentrations observed in soil samples (both at 38-B41) are substantially below the concentrations that would indicate DNAPL, given an organic carbon fraction in soil of 0.01. Given the large difference between observed and the indicator levels it seems unlikely that any DNAPL is present at 38-B41 or the other locations where observed concentrations of PCE and TCE are much lower.

Table 2 – Comparison of observed soil concentrations to concentration associated with DNAPL

Location	Maximum Soil Concentration without DNAPL given foc = 0.01 (ug/kg)	Maximum Observed Soil Concentration (ug/kg)	Difference
38-B41-16.16	PCE = 1,000,000	PCE = 130,000	One order of magnitude
38-B41-16.16	TCE = 1,500,000	TCE = 2,900	Three orders of magnitude

A plausible explanation for the absence of DNAPL is that if it was present, it has now completely dissolved through partitioning into groundwater in the alluvium and diffusion into the underlying Alpine clay. A likely scenario is that observed contamination reflects back diffusion out of the clay. Following Sale (2004), this process is conceptualized in Figures 2 and 3. Others describing this process include Sudicky et al., 1985 and Liu and Ball (2002). Given this, the target for an active remedy would be dissolved and sorbed CVOC in the Alpine Clay immediately below the alluvium.

Simple Case

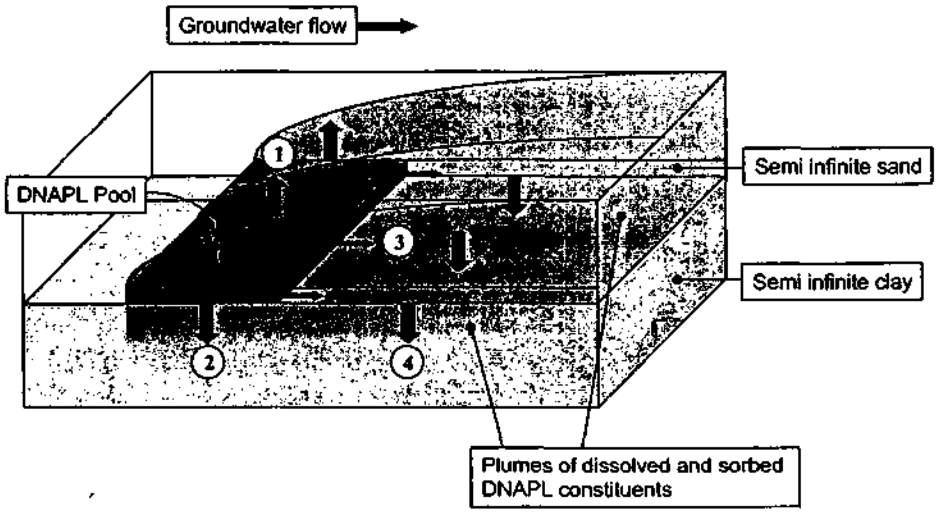


Figure 2 DNAPL Dissolution at Contact

Back Diffusion

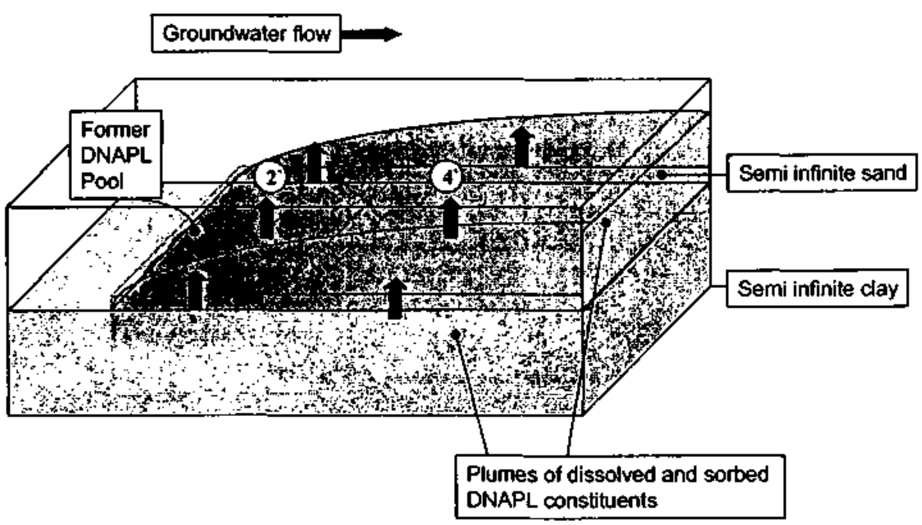


Figure 3 - Back Diffusion from Clay Post DNAPL Dissolution

Remedial Options Assessment

The current remedial actions proposed under Alternative 3 are 1) monitoring the natural attenuation processes of the dissolved phase CVOC plume, and 2) remediating a former/continuing source of solvent impact in the industrial sewer lines. The information presented herein raises the issue of whether additional measures are warranted. The following provides a brief review of the most obvious alternatives for soils observed in the vicinity of borings 38-B41 and 38-B44.

<u>In Situ Chemical Oxidation Using KMnO4</u> – Potassium permanganate (KMnO4) solutions have been used to address low concentrations of chlorinated ethanes in aerobic source areas. Appealing aspects are that the density of permanganate solutions would drive it to the contact with the Alpine Formation and subsequent diffusion into the clay could address the targeted CVOCs. Unfortunately, the permanganate would also adversely affect the anaerobes that are currently controlling CVOC concentrations in the source area and in the downgradient plume. Inhibiting the anaerobic microbial population could have the detrimental effect of increasing concentrations of CVOC in groundwater downgradient of the area of concern. In this case the risks of doing more do not seem to merit the potential benefits.

<u>Excavation</u> – Considering the low levels observed in the soils and the fact that other portions of the site may control the longevity of the plume, it seems that the benefits of excavation are inconsistent to the cost and risk of the action (e.g. exposure associated with excavations below groundwater, transport, and treatment). This alternative seems to provide little advantage over the currently planned site remedy.

<u>Containment</u> – Another option is to surround the area with a physical barrier that would reduce contaminant flux from the areas of concern. As the CVOC plume is currently onsite and stable, the advantages of this are not significant. A detriment might be that reducing the natural flushing (that has historically depleted the source) might increase the longevity of the residual source material. Again, this alternative seems to provide little advantage over the currently planned suite care.

Based on all of the above our recommendation is that the Alternative 3 actions are still the best approach for the AOI's described herein.

References Cited

Simpkin T., T.C. Sale, B.H. Kueper M. Pitts, and K. Wyatt. <u>Surfactants and Cosolvents for NAPL Remediation: A Technology Practices Manual</u>, AATDF Editors. Lowe, D.F., K., Oubre, C.L., Ward, C.H., Lewis Publishers., 1999.

Liu, C. and W.P. Ball, (2002), Back Diffusion of Chlorinated Solvents from a Natural Aquitard to a Remediated Aquifer Under Well-Controlled Field Conditions: Predictions and Measurements, Journal of Groundwater, Vol. 40, No. 2.

Sale, T., T. Illangasekare, F. Marinelli, B. Wilkins, D. Rodriguez and B. Twitchell, (2004), AFCEE Source Zone Initiative – Year One Progress Report, Colorado State University and Colorado School of Mines, Prepared for the Air Force Center for Environmental Excellence.

Sudicky, E.A., R.W. Gillham, and E.O. Frind (1985), Experimental Investigations of Solute Transport in Stratified Porous Media 1) The Non Reactive Case, Water Resource Research Vol 21, No. 7, pp. 1035-1041.

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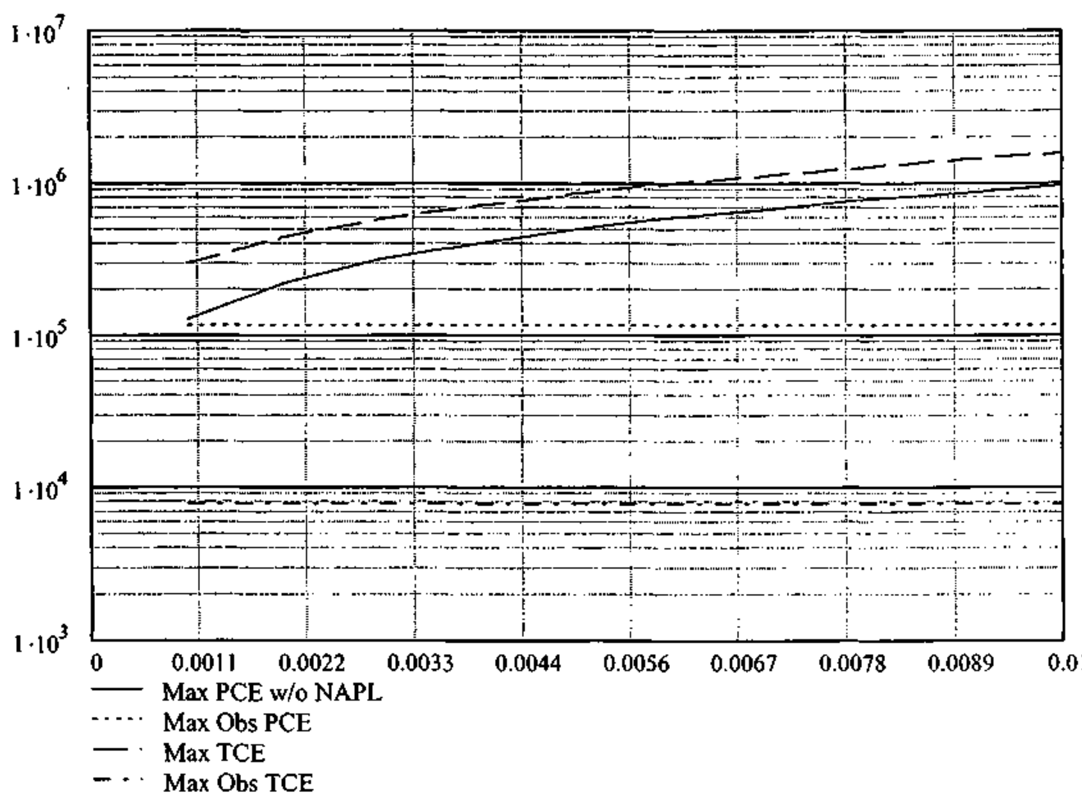
Attachment A – Comparison of observed concentrations to concentration that would indicate the presence of DNAPL

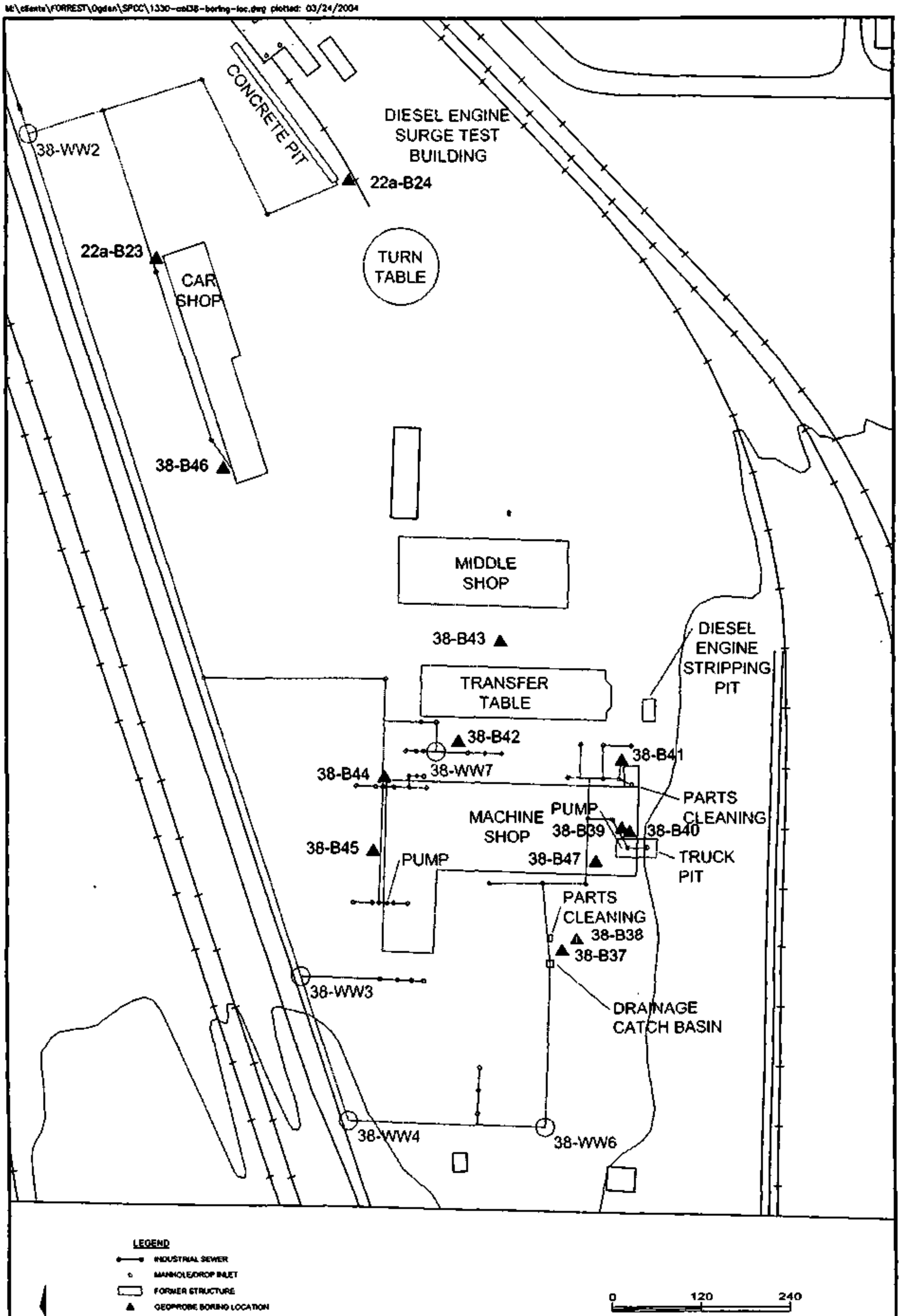
$\phi := 0.27$	Porosity (typical for sandy alluvium)
$\rho_s := 2.65 \cdot \frac{gm}{cm^3}$	Density of Quartz
$f_{oc} := 0.001, 0.002 .. 0.01$	Fraction Organic Carbon in Soil (typical range)
$C_{solTCE} := 1100 \cdot \frac{mg}{L}$	Solubility of TCE in water (Pandkow and Cherry 1996)
$C_{solPCE} := 250 \cdot \frac{mg}{L}$	Solubility of PCE in water (Pandkow and Cherry 1996)
$K_{ocTCE} := 126 \cdot \frac{mL}{gm}$	Octanol Water Partioning Coefficient for TCE (Pankow and Cherry 1996)
$K_{ocPCE} := 364 \cdot \frac{mL}{gm}$	Octanol Water Partioning Coefficient for PCE (Pankow and Cherry 1996)
$\rho_b := \rho_s \cdot (1 - \phi)$	Bulk Density of Soil

$$C_{soil}(K_{oc}, f_{oc}, C_{sol}) := \frac{K_{oc} \cdot f_{oc} \cdot C_{sol} \cdot \rho_b + C_{sol} \cdot \phi}{\rho_b} \qquad \mu g := 1 \cdot \frac{gm}{10^6}$$

$$PCE_{max}(f_{oc}) := 116000 \qquad TCE_{max}(f_{oc}) := 7730$$



M:\clients\FORREST\Ogden\SPCC\1330-aoi38-boring-loc.dwg plotted: 03/24/2004



BY	DATE
RJV	2/5/04

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UNION PACIFIC RAILROAD-OGDEN, UTAH

FIGURE 1

AOI-38 BORING LOCATIONS

SCALE: 1"=120'

DWG. NO.: 1330-aoi38-boring-loc.dwg

Analytical Results Tables

Table 1 - Samples Collected and Analyses Performed

Table 2 - Method 8260 Validated Analytical Results

Table 1
Summary of Samples Collected and Analyses Performed, Soil
UPRR Ogden Railyard
March 2004

Area of Interest	Location	Depth (ft)	Date	VOC
22A	22a-B23	20 - 20.3	3/8/04	X
22A	22A-B24	17.5 - 17.9	3/5/04	X
38	38-B38	16 - 16.5	3/8/04	X
38	38-B40	14 - 16.5	3/8/04	X
38	38-B41	15.8 - 16.2	3/5/04	X
38	38-B42	15.2 - 15.7	3/5/04	X
38	38-B43	17.7 - 18.2	3/5/04	X
38	38-B44	18.2 - 18.7	3/5/04	X
38	38-B45	17.2 - 17.7	3/5/04	X
38	38-B46	16.5 - 17	3/8/04	X
38	38-B47	17.3 - 17.8	3/8/04	X

Table 2
Soil Analytical Data Summary
UPRR Ogden Railyard
March 2004

	AOI	22A	22A	38	38	38	38	38	38	38	38	38
	Location	22a-B23	22A-B24	38-B38	38-B40	38-B41	38-B42	38-B43	38-B44	38-B45	38-B46	38-B47
	Depth (ft)	20-20.3	17.5-17.9	16-16.5	14-16.5	15.8-16.2	15.2-15.7	17.7-18.2	18.2-18.7	17.2-17.7	16.5-17	17.3-17.8
	Date	3/8/2004	3/5/2004	3/8/2004	3/8/2004	3/5/2004	3/5/2004	3/5/2004	3/5/2004	3/5/2004	3/8/2004	3/8/2004
ParameterName	Units											
1,1,1-Trichloroethane	mg/kg	< 0.005	< 0.005	< 0.005	< 0.006	1.6	< 0.005	< 0.006 J	9.2 J	< 0.005	< 0.005	< 0.005
1,1,2,2-Tetrachloroethane	mg/kg	< 0.005	< 0.005	< 0.005	< 0.006	< 0.054	< 0.005	< 0.006 J	< 0.006 J	< 0.005	< 0.005	< 0.005
1,1,2-Trichloroethane	mg/kg	< 0.005	< 0.005	< 0.005	< 0.006	< 0.054	< 0.005	< 0.006 J	< 0.006 J	< 0.005	< 0.005	< 0.005
1,1-Dichloroethane	mg/kg	0.006	< 0.005	< 0.005	< 0.006	0.17	< 0.005	< 0.006 J	0.74 J	< 0.005	0.006	< 0.005
1,1-Dichloroethene	mg/kg	< 0.005	< 0.005	< 0.005	< 0.006	0.096	< 0.005	< 0.006 J	0.13 J	< 0.005	< 0.005	< 0.005
1,2,3-Trichloropropane	mg/kg	< 0.005	< 0.005	< 0.005	< 0.006	< 0.054	< 0.005	< 0.006 J	< 0.006 J	< 0.005	< 0.005	< 0.005
1,2-Dibromo-3-chloropropane (DBCP)	mg/kg	< 0.005	< 0.005	< 0.005	< 0.006	< 0.054	< 0.005	< 0.006 J	< 0.006 J	< 0.005	< 0.005	< 0.005
1,2-Dichloroethane	mg/kg	< 0.005	< 0.005	< 0.005	< 0.006	< 0.054	< 0.005	< 0.006 J	< 0.006 J	< 0.005	< 0.005	< 0.005
1,2-Dichloroethene (total)	mg/kg	< 0.011	0.01 J	< 0.011	< 0.013	1.7	0.006 J	0.006 J	22 J	0.002 J	0.002 J	< 0.011
1,2-Dichloropropane	mg/kg	< 0.005	< 0.005	< 0.005	< 0.006	< 0.054	< 0.005	< 0.006 J	< 0.006 J	< 0.005	< 0.005	< 0.005
1,4-Dioxane	mg/kg	< 0.54	< 0.54 R	< 0.54 R	< 0.64 R	< 5.4 R	< 0.54 R	< 0.56 R	< 0.6 R	< 0.52 R	< 0.54 R	< 0.53 R
2-Butanone (MEK)	mg/kg	< 0.011	< 0.011	< 0.011	< 0.013	< 0.11	< 0.011	< 0.011 J	< 0.012 J	< 0.01	< 0.011	< 0.011
2-Chloroethylvinyl ether	mg/kg	< 0.011	< 0.011	< 0.011	< 0.013	< 0.11	< 0.011	< 0.011 J	< 0.012 J	< 0.01	< 0.011	< 0.011
2-Hexanone	mg/kg	< 0.011	< 0.011	< 0.011	< 0.013	< 0.11	< 0.011	< 0.011 J	< 0.012 J	< 0.01	< 0.011	< 0.011
4-Methyl-2-pentanone (MIBK)	mg/kg	< 0.011	< 0.011	< 0.011	0.002 J	< 0.11	< 0.011	< 0.011 J	< 0.012 J	< 0.01	< 0.011	< 0.011
Acetone	mg/kg	< 0.011	< 0.013	< 0.005	< 0.012	< 0.11	< 0.003	< 0.011 J	< 0.012 J	< 0.01	< 0.003	< 0.011
Acetonitrile	mg/kg	< 0.011	< 0.011	< 0.011	< 0.013	< 0.11	< 0.011	< 0.011 J	< 0.012 J	< 0.01	< 0.011	< 0.011
Acrolein	mg/kg	< 0.027 R	< 0.027 R	< 0.027 R	< 0.032 R	< 0.27 R	< 0.027 R	< 0.028 R	< 0.03 R	< 0.026 R	< 0.027 R	< 0.027 R
Acrylonitrile	mg/kg	< 0.027	< 0.027	< 0.027	< 0.032	< 0.27	< 0.027	< 0.028 J	< 0.03 J	< 0.026	< 0.027	< 0.027
Benzene	mg/kg	< 0.005	< 0.005	< 0.005	< 0.006	< 0.054	< 0.005	< 0.006 J	< 0.006 J	< 0.005	< 0.005	< 0.005
Bromodichloromethane	mg/kg	< 0.005	< 0.005	< 0.005	< 0.006	< 0.054	< 0.005	< 0.006 J	< 0.006 J	< 0.005	< 0.005	< 0.005
Bromoform	mg/kg	< 0.005	< 0.005	< 0.005	< 0.006	< 0.054	< 0.005	< 0.006 J	< 0.006 J	< 0.005	< 0.005	< 0.005
Bromomethane (Methyl bromide)	mg/kg	< 0.011	< 0.011	< 0.011	< 0.013	< 0.11	< 0.011	< 0.011 J	< 0.012 J	< 0.01	< 0.011	< 0.011
Carbon disulfide	mg/kg	< 0.005	< 0.005	0.004 J	< 0.006	0.047 J	< 0.005	< 0.006 J	0.019 J	0.005 J	0.007	< 0.005
Carbon tetrachloride	mg/kg	< 0.005	< 0.005	< 0.005	< 0.006	< 0.054	< 0.005	< 0.006 J	< 0.006 J	< 0.005	< 0.005	< 0.005
Chlorobenzene	mg/kg	< 0.005	< 0.005	< 0.005	< 0.006	< 0.054	< 0.005	< 0.006 J	< 0.006 J	< 0.005	< 0.005	< 0.005
Chloroethane (Ethyl chloride)	mg/kg	< 0.011	< 0.011	< 0.011	< 0.013	< 0.11	< 0.011	< 0.011 J	< 0.012 J	< 0.01	< 0.011	< 0.011
Chloroform	mg/kg	< 0.005	< 0.005	< 0.005	< 0.006	< 0.054	< 0.005	< 0.006 J	< 0.006 J	< 0.005	< 0.005	< 0.005
Chloromethane (Methyl chloride)	mg/kg	< 0.011	< 0.011	< 0.011	< 0.013	< 0.11	< 0.011	< 0.011 J	< 0.012 J	< 0.01	< 0.011	< 0.011
cis-1,2-Dichloroethene	mg/kg	< 0.005	0.01	< 0.005	< 0.006	1.7	0.006	0.006 J	22 J	0.002 J	0.002 J	< 0.005
cis-1,3-Dichloropropene	mg/kg	< 0.005	< 0.005	< 0.005	< 0.006	< 0.054	< 0.005	< 0.006 J	< 0.006 J	< 0.005	< 0.005	< 0.005
Dibromochloromethane	mg/kg	< 0.005	< 0.005	< 0.005	< 0.006	< 0.054	< 0.005	< 0.006 J	< 0.006 J	< 0.005	< 0.005	< 0.005
Dichloromethane	mg/kg	0.013	0.009 J	0.013	< 0.013	< 0.11	< 0.011	0.004 J	0.007 J	< 0.01	0.012	0.013
Ethylbenzene	mg/kg	< 0.005	< 0.005	< 0.005	< 0.006	0.18	< 0.005	< 0.006 J	0.029 J	< 0.005	< 0.005	< 0.005
Ethylene dibromide (EDB)	mg/kg	< 0.005	< 0.005	< 0.005	< 0.006	< 0.054	< 0.005	< 0.006 J	< 0.006 J	< 0.005	< 0.005	< 0.005

<# = undetected at reporting limit
<# J = undetected at estimated reporting limit
<# R [illegible]cted at estimated reporting limit

J = estimated
[illegible]R = rejected

Table 2
Soil Analytical Data Summary
UPRR Ogden Railyard
March 2004

	AOI	22A	22A	38	38	38	38	38	38	38	38	38
	Location	22a-B23	22A-B24	38-B38	38-B40	38-B41	38-B42	38-B43	38-B44	38-B45	38-B46	38-B47
	Depth (ft)	20-20.3	17.5-17.9	16-16.5	14-16.5	15.8-16.2	15.2-15.7	17.7-18.2	18.2-18.7	17.2-17.7	16.5-17	17.3-17.8
	Date	3/8/2004	3/5/2004	3/8/2004	3/8/2004	3/5/2004	3/5/2004	3/5/2004	3/5/2004	3/5/2004	3/8/2004	3/8/2004
ParameterName	Units											
Hexane	mg/kg	< 0.005	< 0.005	< 0.005	< 0.006	< 0.054	< 0.005	< 0.006 J	0.016 J	< 0.005	< 0.005	< 0.005
Isobutanol (2-Methyl-1-propanol)	mg/kg	< 0.054 R	< 0.054 R	< 0.054 R	< 0.064 R	< 0.54 R	< 0.054 R	< 0.056 R	< 0.06 R	< 0.052 R	< 0.054 R	< 0.053 R
Methacrylonitrile	mg/kg	< 0.011	< 0.011	< 0.011	< 0.013	< 0.11	< 0.011	< 0.011 J	< 0.012 J	< 0.01	< 0.011	< 0.011
Styrene	mg/kg	< 0.005	< 0.005	< 0.005	< 0.006	0.013 J	< 0.005	< 0.006 J	< 0.006 J	< 0.005	< 0.005	< 0.005
Tetrachloroethene	mg/kg	< 0.005	0.002 J	< 0.005	0.001 J	130 J	< 0.005	< 0.006 J	27 J	< 0.005	< 0.005	< 0.005
Toluene	mg/kg	< 0.005	< 0.005	< 0.005	< 0.006	0.067	< 0.005	< 0.006 J	0.21 J	< 0.005	< 0.005	< 0.005
trans-1,2-Dichloroethene	mg/kg	< 0.005	< 0.005	< 0.005	< 0.006	< 0.054	< 0.005	< 0.006 J	0.011 J	< 0.005	< 0.005	< 0.005
trans-1,3-Dichloropropene	mg/kg	< 0.005	< 0.005	< 0.005	< 0.006	< 0.054	< 0.005	< 0.006 J	< 0.006 J	< 0.005	< 0.005	< 0.005
Trichloroethene	mg/kg	< 0.005	< 0.005	< 0.005	< 0.006	1.4	< 0.005	< 0.006 J	1.2 J	< 0.005	< 0.005	< 0.005
Trichlorofluoromethane	mg/kg	< 0.011	< 0.011	< 0.011	< 0.013	< 0.11	< 0.011	< 0.011 J	< 0.012 J	< 0.01	< 0.011	< 0.011
Vinyl acetate	mg/kg	< 0.011	< 0.011	< 0.011	< 0.013	< 0.11	< 0.011	< 0.011 J	< 0.012 J	< 0.01	< 0.011	< 0.011
Vinyl chloride	mg/kg	< 0.011	< 0.011	< 0.011	< 0.013	< 0.11	< 0.011	< 0.011 J	0.52 J	< 0.01	0.003 J	< 0.011
Xylenes (Total)	mg/kg	< 0.016	< 0.016	< 0.016	0.002 J	0.74	< 0.016	< 0.017 J	0.15 J	< 0.016	< 0.016	< 0.016

<# = undetected at reporting limit
<# J = undetected at estimated reporting limit
<# R = rejected at estimated reporting limit

J = estimated
R = rejected

CH2MHILL

PROJECT NUMBER:	179206.SP.04	BORING NUMBER:	22a-B23	SHEET 1 OF 1

SOIL BORING LOG

PROJECT: UPRR
START: 3/8/2004
FINISH: 3/8/2004
LOCATION: Odgen RR
AREA: AOI 22a
LOGGER: Terence Mares & Aaron Galer
DRILLING SUBCONTRACTOR: EarthProbe
DRILLING METHOD AND EQUIPMENT: Truck Mounted Geoprobe 6600

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
		3.5	SP	Sands - with gravels, brown, dry, dense – black staining	0 OVM
			SM	3.3' - Silty - with fine sands, brown, moist, med dense, low plasticity	
5		4.0			26.8 OVM
10		2.3	GW	9.3' - Gravel - with sands, grey, very moist, and loose – 9.3' HC sheen to end of sample – 12.8' HC sheen to end of sample	16.8 OVM
15					Sampling sleeve stuck. Drillers had to pound out sample.
20		4.8	MH	20.3' - Silty - Clayey	2.1 OVM
25				Collected soil sample above clay contact layer at 0820 Top of clay at 20.3' Total depth 25.0' Hole plugged with Bentonite	

CH2MHILL

PROJECT NUMBER: 179206.SP.04	BORING NUMBER: 22a-B24	SHEET 1 OF 1

SOIL BORING LOG

PROJECT: UPRR START: 3/5/2004 FINISH: 3/5/2004
LOCATION: Odgen RR AREA: AOI 22a LOGGER: Terence Mares & Aaron Galer
DRILLING SUBCONTRACTOR: EarthProbe DRILLING METHOD AND EQUIPMENT: Truck Mounted Geoprobe 5400

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
		3.4	SP	Sands - with gravels, brown, dry, dense -- black staining	0 OVM
5		4.7	SM	3.9' - Silty - with fine sands, brown, moist, med dense, low plasticity	0 OVM
10		2.2	GW	9.5' - Gravel - with sands, grayish brown, saturated, and loose	0.9 OVM
15		4.3			0 OVM
			MH	17.9' - Silty - Clayey	
20				Collected soil sample above clay contact layer at 0931 Top of clay at 17.9' Total depth 20.0' *Hole plugged with Bentonite*	

CH2MHILL	PROJECT NUMBER: 179206.SP.04	BORING NUMBER: 38-B37	SHEET 1 OF 1
	SOIL BORING LOG		

PROJECT: UPRR — START: 3/4/2004 — FINISH: 3/4/2004
LOCATION: Ogden RR — AREA: AOI-38 — LOGGER: Terence Mares & Aaron Galer
DRILLING SUBCONTRACTOR: EarthProbe — DRILLING METHOD AND EQUIPMENT: Truck Mounted Geoprobe 5400

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
				0.4' of concrete	
		.5	GW	Gravel - sands with some fines, brown, moist, and loose	0 OVM
5		2.8			0 OVM
			SM	5.6' - Silty - with fine sands, brown, moist, med. dense, low plasticity	
			GP	6.5' - Gravel - with silty sands, brown, moist, and loose	
			SP	8.5' - Sand - with gravels, grey, saturated, loose -- 10.6' HC sheen	
10		3.1			0 OVM
			GM	10.7' - Silts - with gravels, dark brown, saturated, med. dense	
			GW	12' - Gravel - with well graded sands, brown, saturated, and loose	0 OVM
		4.0			
15				-- 15.4 to 15.7' HC sheen	
			SM	15.6' - Silty - with fine sands, brown, saturated, med. dense	
			GW	16.3' - Gravel - with well graded sands, light brown, saturated, and loose	
		3.3			0 OVM
20			MH	19.2' - Silty - Clayey	
				-- Sampling sleeve stuck. Drillers had to pound sampler to get sleeve out, which may have moved soil sample inside the tube. Use Boring Log 38-B38 for actual clay depth.	
				No sample obtained Total depth 20' Hole plugged with Bentonite	

CH2MHILL

PROJECT NUMBER:	179206.SP.04	BORING NUMBER:	38-B38	SHEET 1 OF 1

SOIL BORING LOG

PROJECT: UPRR START: 3/4/2004 FINISH: 3/8/2004
LOCATION: Odgen RR AREA: AOI 38 LOGGER: Terence Mares & Aaron Gafer
DRILLING SUBCONTRACTOR: EarthProbe DRILLING METHOD AND EQUIPMENT: Truck Mounted Geoprobe 5400 and 6600

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
				0.4' of concrete	
		2.2	SP	Sand - with gravels, brown, moist, loose ~ 1.9 - 2' black staining	0 OVM
			SM	1.9' - Silty - with fine sands, dark brown, moist, med. dense, med. plasticity	
5		3.0			2.1 OVM
			GW	7.3' - Gravel - sands with some fines, brown, moist, and loose ~ 7.3' HC sheen ~ 9.0' grey, saturated	
10		2.2			0 OVM
15		1.6			0 OVM
			MH	16.5' - Silty - Clayey	0 OVM
20					
				~ Combined log with two geoprobe borings two feet apart. First boring used single tube method with a 1.5" sampling sleeve and could not get discrete sample between clay and soils above due to 2" gravels. Second boring used dual tube method with a 2" sampling sleeve. We were able to obtain a discrete sample between the clay and soils above. Collected soil sample above clay contact layer at 0926 Top of clay at 16.5' Total depth 20' Hole plugged with Bentonite	

CH2MHILL

PROJECT NUMBER: 179206.SP.04 | BORING NUMBER: 38-B39 | SHEET 1 OF 1

SOIL BORING LOG

PROJECT: UPRR | START: 3/4/2004 | FINISH: 3/5/2004

LOCATION: Odgen RR | AREA: AOI 38 | LOGGER: Terence Mares & Aaron Galer

DRILLING SUBCONTRACTOR: EarthProbe | DRILLING METHOD AND EQUIPMENT: Truck Mounted Geoprobe 5400 and 6600

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
		3.0	SP	Sands - brown, moist, and loose	0 OVM
			GW	2.1' - Gravel - sands, reddish brown, dry, and med. Stiff – 2.1 - 2.7' black staining	
5		4.0		– 7.2' increasing sand content – 7.2 - 7.6' back fill containing organics, bricks, glass, and concrete – 7.6' black staining and moist	0 OVM
10		0.6		– 11.4 saturated	0 OVM
15		3.0			Drillers felt pushing became easy around 15'. Rock stuck in shoe. Clay on shoe and around rock. 0 OVM
20				– Attempted three other borings in this area using the dual tube method with the 2" sampling sleeve. Drillers were not able to collect a discrete sample between the clay and the soils above due to 2 - 3" gravels. Added an extra boring where this area drained to (38-B47). At this location the drillers were able to collect a discrete sample. No sample obtained Total depth 16' Hole plugged with Bentonite	

CH2MHILL

PROJECT NUMBER:	179206.SP.04	BORING NUMBER:	38-B40	SHEET 1 OF 1

SOIL BORING LOG

PROJECT: UPRR **START:** 3/4/2004 **FINISH:** 3/5/2004

LOCATION: Odgen RR **AREA:** AOI 38 **LOGGER:** Terence Mares & Aaron Galer

DRILLING SUBCONTRACTOR: EarthProbe **DRILLING METHOD AND EQUIPMENT:** Truck Mounted Geoprobe 5400 and 6600

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
			SP	Sands - brown, moist, and med. stiff	
		2.6	GW	1.8' - Gravel - sands, reddish brown, dry, and med. stiff -- 3.2' moist	0 OVM
5		3.3		-- 5.8' very moist -- 6.2' increasing sand content	0 OVM
				-- 8.0' saturated	
10		4.0			Hit refusal at 10'. Drillers preprobed from 10 - 12' then advanced sampler. Bent sampler.
15		4.0			3.6 OVM Hit refusal at 16.5'. Drillers tried to preprobe but bent rods.
20				-- Attempted two other borings in this area using the dual tube method with the 2" sampling sleeve. Drillers were not able to collect a discrete sample between the clay and the soils above due to 2 - 3" gravels. Added an extra boring where this area drained to (38-B47). At this location the drillers were able to collect a discrete sample. -- Collected sample from 14 - 16.5'. Concrete in bottom of shoe.	
				Collected soil sample above concrete at 1100 Total depth 16.5' Hole plugged with Bentonite	

CH2MHILL

PROJECT NUMBER:	179206.SP.04	BORING NUMBER:	38-B41	SHEET 1 OF 1

SOIL BORING LOG

PROJECT: UPRR START: 3/4/2004 FINISH: 3/5/2004
LOCATION: Odgen RR AREA: AOI 38 LOGGER: Terence Mares & Aaron Galer
DRILLING SUBCONTRACTOR: EarthProbe DRILLING METHOD AND EQUIPMENT: Truck Mounted Geoprobe 5400 and 6600

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
				0.4' of concrete	
		2.0	SM	0.4' - Silty - with fine sands, dark brown, slightly moist, med. dense, low plasticity -- 2.2' moist	0 OVM
5		2.3	GW	5.9' - Gravel - sands with some fines, dark brown, very moist, and loose -- 6.6' HC sheen -- 6.7' HC residual to end of sample	208 OVM at 7.7'
10		3.3		-- 9.9' HC globlets -- 10.7' HC residual to end of sample	40 OVM
				-- 12.0' HC residual to end of sample	39 OVM
15		3.3			21.4 OVM On second boring collected sample between 13.5 - 18.5'.
			MH	16.2' - Silty - Clayey	
20				-- Combined log with two geoprobe borings two feet apart. First boring used single tube method with a 1.5" sampling sleeve and could not get discrete sample between clay and soils above due to 2" gravels. Second boring used dual tube method with a 2" sampling sleeve. We were able to obtain a discrete sample between the clay and soils above. Collected soil sample above clay contact layer at 1228 Top of clay at 16.2' Total depth 18.5' Hole plugged with Bentonite	

PROJECT NUMBER: 179206.SP.04	BORING NUMBER: 38-B42	SHEET 1 OF 1

CH2MHILL

SOIL BORING LOG

PROJECT: UPRR
START: 3/4/2004
FINISH: 3/5/2004
LOCATION: Odgen RR
AREA: AOI 38
LOGGER: Terence Mares & Aaron Galer
DRILLING SUBCONTRACTOR: EarthProbe
DRILLING METHOD AND EQUIPMENT: Truck Mounted Geoprobe 5400 and 6600

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
		2.6	SP	Sands - brown, moist, med. dense, and black staining	0 OVM
			SM	2.6' - Silty - with fine sands, dark brown, slightly moist, med. dense, low plasticity	
5		2.9		– 5.4' grey	
			GW	6.6' - Gravel - sands with some fines, dark brown, very moist, and loose – 7.1' increasing sands	0 OVM
			SM	8.0' - Silty - with fine sands, dark brown, saturated, med plasticity	
10		4.0	SP	8.8' - Sands - grey, saturated, and med. dense	7 OVM
			GW	10.6' - Gravel - sands with some fines, dark brown, very moist, and loose – 7.1' increasing sands	
		2.7		– 13.4 - 14.7' HC sheen	11 OVM
15					
			MH	15.7' - Silty - Clayey	0 OVM On second boring collected sample between 14.0 - 18.5'.
20				– Combined log with two geoprobe borings two feet apart. First boring used single tube method with a 1.5" sampling sleeve and could not get discrete sample between clay and soils above due to 2" gravels. Second boring used dual tube method with a 2" sampling sleeve. We were able to obtain a discrete sample between the clay and soils above. Collected soil sample above clay contact layer at 1110 Top of clay at 15.7' Total depth 18.5' Hole plugged with Bentonite	

CH2MHILL

PROJECT NUMBER: 179206.SP.04	BORING NUMBER: 38-B43	SHEET 1 OF 1

SOIL BORING LOG

PROJECT: UPRR START: 3/4/2004 FINISH: 3/5/2004
LOCATION: Odgen RR AREA: AOI 38 LOGGER: Terence Mares & Aaron Galer
DRILLING SUBCONTRACTOR: EarthProbe DRILLING METHOD AND EQUIPMENT: Truck Mounted Geoprobe 5400 and 6600

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
		3.1	SP	Sands - with gravels, brown, moist, med. dense, and black staining	0 OVM
			SM	2.1' - Silty - with fine sands, brown, slightly moist, med. dense, low plasticity	
5		2.7	GW	5.9' - Gravel - sands with some fines, brown, very moist, and loose	
				– 7.5' HC residual to end of sample	2 OVM
10		4.0		– 10.2' HC globlets	0 OVM
					0 OVM
15		0.7			Rock stuck in shoe. Poor recovery.
		4.0			On second boring collected sample between 16.0 - 20.0'.
			MH	18.2' - Silty - Clayey	
20				– Combined log with two geoprobe borings two feet apart. First boring used single tube method with a 1.5" sampling sleeve and could not get discrete sample between clay and soils above due to 2" gravels. Second boring used dual tube method with a 2" sampling sleeve. We were able to obtain a discrete sample between the clay and soils above.	
				Collected soil sample above clay contact layer at 1009 Top of clay at 18.2' Total depth 20.0' Hole plugged with Bentonite	

CH2MHILL

PROJECT NUMBER:	179206.SP.04	BORING NUMBER:	38-B44	SHEET 1 OF 1

SOIL BORING LOG

PROJECT: UPRR | START: 3/5/2004 | FINISH: 3/5/2004

LOCATION: Odgen RR | AREA: AOI 38 | LOGGER: Terence Mares & Aaron Galer

DRILLING SUBCONTRACTOR: EarthProbe | DRILLING METHOD AND EQUIPMENT: Truck Mounted Geoprobe 6600

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
0–5					Drillers did not collect sample
5–10		3.8	SM	6.1' - Silty - with fine sands, grey, moist, soft, low plasticity	1.9 OVM
			SP	8.0' - Sands - with fines, grey, very moist, loose	
			GW	8.8' - Gravel - with sands, grey, saturated, and loose	
10–15		2.5		-- black fluid on top of gravels in sleeve -- 13.4 - 13.8' residual HC	15.4 OVM
15–20		3.4			16.8 OVM
			MH	18.7' - Silty - Clayey	
20				Collected soil sample above clay contact layer at 1446 Top of clay at 18.7' Total depth 20.0' Hole plugged with Bentonite	

CH2MHILL

PROJECT NUMBER:	179206.SP.04	BORING NUMBER:	38-B45	SHEET 1 OF 1

SOIL BORING LOG

PROJECT: UPRR START: 3/5/2004 FINISH: 3/5/2004
LOCATION: Odgen RR AREA: AOI 38 LOGGER: Terence Mares & Aaron Galer
DRILLING SUBCONTRACTOR: EarthProbe DRILLING METHOD AND EQUIPMENT: Truck Mounted Geoprobe 6600

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
				0.3' of concrete	
		2.0	SP	0.3' - Sands - with fines, brown, moist, loose – 1.0' black staining	23.9 OVM
5		3.75			12.4 OVM
			GW	8.6' - Gravel - with sands, grey, very moist to saturated, and loose – 9.2' black staining to end of sample	
10		3.3		– 13.8 - 14.1' increasing sand content	4 OVM
			SM	14.1' - Silty - with fine sands, grayish brown, saturated, med dense, med plasticity	
15		3.9			20.3 OVM
			MH	17.7' - Silty - Clayey	
20				Collected soil sample above clay contact layer at 1524 Top of clay at 17.7' Total depth 20.0' Hole plugged with Bentonite	

CH2MHILL

PROJECT NUMBER: 179206.SP.04	BORING NUMBER: 38-B46	SHEET 1 OF 1

SOIL BORING LOG

PROJECT: UPRR | START: 3/4/2004 | FINISH: 3/8/2004
LOCATION: Odgen RR | AREA: AOI 38 | LOGGER: Terence Mares & Aaron Galer
DRILLING SUBCONTRACTOR: EarthProbe | DRILLING METHOD AND EQUIPMENT: Truck Mounted Geoprobe 5400

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
		3.3	SP	Sands - with gravels, brown, dry, loose – black staining throughout	31 OVM
5			SM	3.6' - Silty - with fine sands, grey, moist, med dense, low plasticity – very moist to saturated	
		5.0			2.5 OVM
10		5.0	SP	10.0 - Sands - with silts, grey, saturated, no plasticity	1.0 OVM
			GW	12.6' - Gravel - with sands, grey, saturated, and loose	
15		4.3			0.5 OVM
			MH	17.0' - Silty - Clayey	
20				Collected soil sample above clay contact layer at 0850 Top of clay at 17.0' Total depth 20.0' Hole plugged with Bentonite	

P:\163145\Boringlogs\OU10\AOI38_UPRR logs

3/16/2004

CH2MHILL

PROJECT NUMBER:	179206.SP.04	BORING NUMBER:	38-B47	SHEET 1 OF 1

SOIL BORING LOG

PROJECT: UPRR **START:** 3/5/2004 **FINISH:** 3/8/2004
LOCATION: Odgen RR **AREA:** AOI 38 **LOGGER:** Terence Mares & Aaron Galer
DRILLING SUBCONTRACTOR: EarthProbe **DRILLING METHOD AND EQUIPMENT:** Truck Mounted Geoprobe 6600

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
		2.3	SM	Silty - with fine sands, brown, moist, med dense, low plasticity	0 OVM
				– 3.4' some gravels and black staining	
5		2.8			Dense from 6 - 8'. Took 20 minutes to get through.
					0 OVM
			GW	7.4' - Gravel - with sands, grey, very moist, and loose	
10		2.2		– 12.7' HC sheen	10 OVM
				– 12.7 - 13.0' HC globlets	
15		3.8		– 16.3' increasing sand content	4.1 OVM
			MH	17.8' - Silty - Clayey	
20				Collected soil sample above clay contact layer at 1130 Top of clay at 17.8' Total depth 20.0' Hole plugged with Bentonite	

Pipe Graphic Report of PLR 38-WW8 A for CH2M HILL

Works Order Number	***Cassette*** 1	***Surveyed On*** 12/22/2003	***Setup*** 9
Facility	***Operator*** TODO	***Van Reference*** 1	***Weather*** SNOW

Road Name SP AREA ***Place Name*** OGDEN
Location type
Surface
Survey purpose LOOKING FOR AN UNKNOWN PROBLEM

Pipe Use SANITAIRY SEWER	***Schedule length*** 100.0 ***Ft***	***From*** 38-WW8 ***Depth*** ***Ft***
Shape Circular	***Size*** 10 ***by*** ***Ins***	***To*** 38A-WW6 ***Depth*** ***Ft***
Material STEAL	***Joint spacing*** 13.0 ***Ft***	***Direction*** Down
Lining STEEL	***Year laid*** 0	***Pre-clean*** ***Last cleaned***

General note
Location note

Structural Service Constructional
Miscellaneous Hydraulic

Distance (Ft)	Description (Showing categories: Structural Service Constructional Miscellaneous)	Media
100.0	38A-WW6 (Downstream. Depth = Ft) Tape end:	
15.6	Survey abandoned [DIRTY]	
0.0	Water level 0	
0.0	38-WW8 (Upstream. Depth = Ft) Tape start:0000	

Pipe Graphic Report of PLR 38A-WW6 A for CH2M HILL

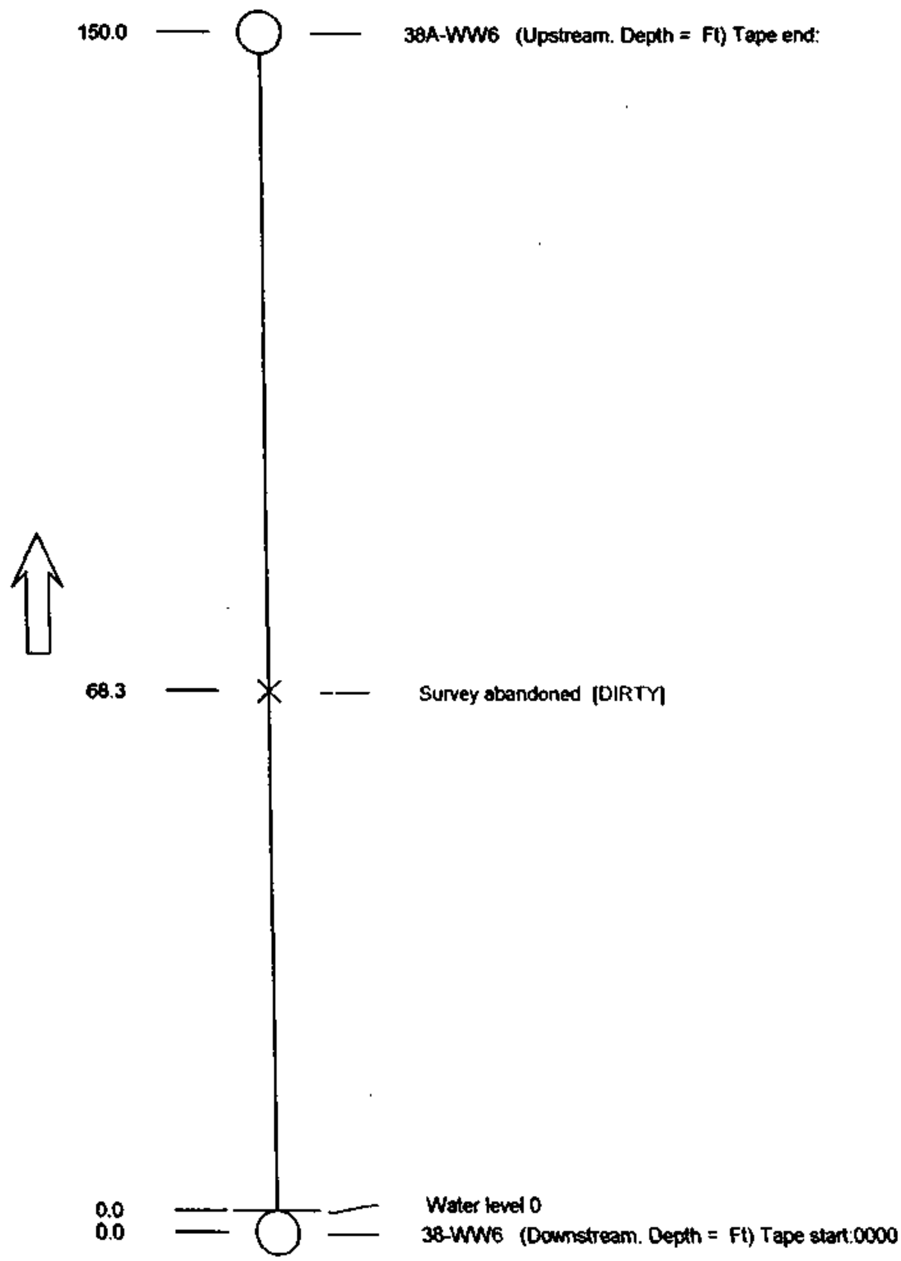
Works Order Number	**Cassette** 1	**Surveyed On** 12/22/2003	**Setup** 6
Facility **Operator** TODD	**Van Reference** 1	**Weather** SNOW	

Road Name SP AREA **Place Name** OGDEN
Location type
Surface
Survey purpose LOOKING FOR AN UNKNOWN PROBLEM

Pipe Use SANITAIRY SEWER	**Schedule length** 150.0 **Ft**	**From** 38-WW6 **Depth** **Ft**
Shape Circular	**Size** 6 **by** **Ins**	**To** 38A-WW6 **Depth** **Ft**
Material WHITE PLASTIC	**Joint spacing** 13.0 **Ft**	**Direction** Up
Lining WHITE PLASTIC	**Year laid** 0	**Pre-clean** **Last cleaned**

General note	Structural Service Constructional
Location note	Miscellaneaous Hydraulic

Distance (Ft) Description (Showing categories: Structural Service Constructional Miscellaneaous) Media



Pipe Graphic Report of PLR 38-WW6 A for CH2M HILL

Works Order Number		**Cassette** 1	**Surveyed On** 12/22/2003 **Setup** 7/7
Facility	**Operator** TODD	**Van Reference** 1	**Weather** SNOW

Road Name SP AREA **Place Name** OGDEN
Location type
Surface
Survey purpose LOOKING FOR AN UNKNOWN PROBLEM

Pipe Use SANITAIRY SEWER	**Schedule length** 150.0 **Ft**	**From** 38-WW6 **Depth** **Ft**
Shape Circular	**Size** 6 **by** **Ins**	**To** 38A-WW7 **Depth** **Ft**
Material WHITE PLASTIC	**Joint spacing** 13.0 **Ft**	**Direction** Down
Lining WHITE PLASTIC	**Year laid** 0	**Pre-clean** **Last cleaned**

General note	Structural Service Constructional
Location note	Miscellaneaous Hydraulic

Distance (Ft)	Description (Showing categories: Structural Service Constructional Miscellaneaous)	Media
150.0	38A-WW7 (Downstream. Depth = Ft) Tape end:	
10.6	Survey abandoned [DIRTY]	
0.0	Water level 0	
0.0	38-WW6 (Upstream. Depth = Ft) Tape start:0000	

Pipe Graphic Report of PLR 38A-WW3 A for CH2M HILL

Works Order Number	**Cassette** 1	**Surveyed On** 12/22/2003	**Setup** 8
Facility **Operator** TODD	**Van Reference** 1	**Weather** SNOW	

Road Name SP AREA **Place Name** OGDEN
Location type
Surface
Survey purpose LOOKING FOR AN UNKNOWN PROBLEM

Pipe Use SANITAIRY SEWER	**Schedule length** 62.6 **Ft**	**From** 38-WW3 **Depth** **Ft**
Shape Circular	**Size** 6 **by** **Ins**	**To** 38A-WW3 **Depth** **Ft**
Material WHITE PLASTIC	**Joint spacing** 13.0 **Ft**	**Direction** Up
Lining WHITE PLASTIC	**Year laid** 0	**Pre-clean** **Last cleaned**

General note
Location note

Structural Service Constructional
Miscellaneous Hydraulic

Distance (Ft)	Description (Showing categories: Structural Service Constructional Miscellaneaous)	Media
62.6	38A-WW3 (Upstream. Depth = Ft) Tape end:	
0.0	Water level 0	
0.0	38-WW3 (Downstream. Depth = Ft) Tape start:0000	

Pipe Graphic Report of PLR 38-WW3 A for CH2M HILL

Works Order Number	***Cassette*** 1	***Surveyed On*** 12/22/2003	***Setup*** 4/5
Facility ***Operator*** TODD	***Van Reference*** 1	***Weather*** SNOW	

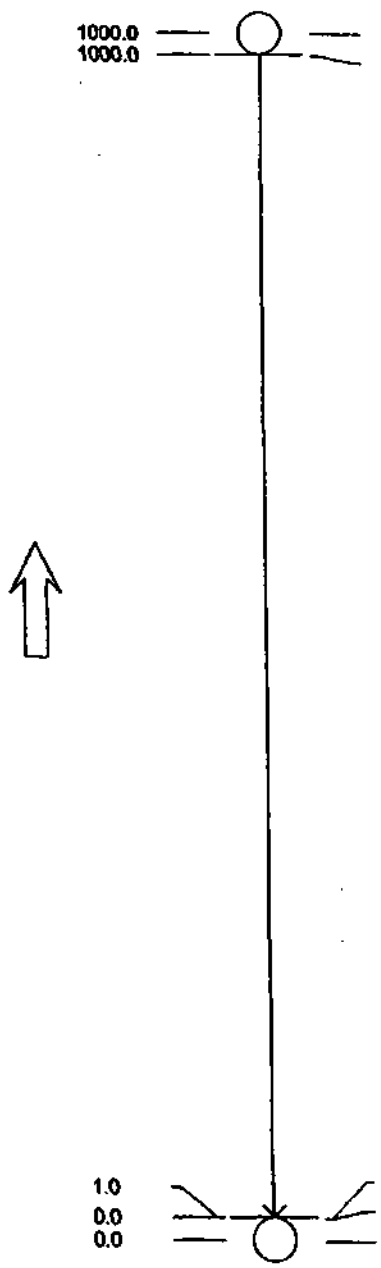
Road Name SP AREA ***Place Name*** OGDEN
Location type
Surface
Survey purpose LOOKING FOR AN UNKNOWN PROBLEM

Pipe Use SANITAIRY SEWER	***Schedule length*** 1000.0 ***Ft***	***From*** 38-WW3 ***Depth*** ***Ft***
Shape Circular	***Size*** 10 ***by*** ***ins***	***To*** 34-WW2 ***Depth*** ***Ft***
Material CLAY	***Joint spacing*** 4.00 ***Ft***	***Direction*** Down
Lining CLAY	***Year laid***	***Pre-clean*** ***Last cleaned***

General note
Location note

Structural Service Constructional
Miscellaneaous Hydraulic

Distance (Ft)	Description (Showing categories: Structural Service Constructional Miscellaneaous)	Media
1000.0	34-WW2 (Downstream. Depth = Ft) Tape end:	
1000.0	Water level 0	
1.0	Survey abandoned [DIRTY WATER CAN'T SEE]	
0.0	Water level 0	
0.0	38-WW3 (Upstream. Depth = Ft) Tape start:0000	



Pipe Graphic Report of PLR 38-WW~~4~~ 3 A for CH2M HILL

Works Order Number	**Cassette** 1	**Surveyed On** 12/22/2003	**Setup** 3/2
Facility **Operator** TODD	**Van Reference** 1	**Weather** SNOW	

Road Name SP AREA **Place Name** OGDEN
Location type
Surface
Survey purpose LOOKING FOR AN UNKNOWN PROBLEM

Pipe Use SANITAIRY SEWER	**Schedule length** 150.0 **Ft**	**From** 38-WW3 **Depth** **Ft**
Shape Circular	**Size** 10 **by** **Ins**	**To** 38-WW4 **Depth** **Ft**
Material CLAY	**Joint spacing** 4.00 **Ft**	**Direction** Up
Lining CLAY	**Year laid**	**Pre-clean** **Last cleaned**

General note
Location note

Structural Service Constructional
Miscellaneaous Hydraulic

Distance (Ft)	Description (Showing categories: Structural Service Constructional Miscellaneaous)	Media
150.0	38-WW4 (Upstream. Depth = Ft) Tape end:	
150.0	Water level 0	
135.2	Survey abandoned [DIRTY]	
1.0	Manhole/Node [38-WW4] 3	
0.0	Water level 0	
0.0	38-WW3 (Downstream. Depth = Ft) Tape start:0000	

Pipe Graphic Report of PLR 38A-WW4 A for CH2M HILL

Works Order Number	***Cassette*** 1	***Surveyed On*** 12/22/2003	***Setup*** 1
Facility ***Operator*** TODD	***Van Reference*** 1	***Weather*** SNOW	

Road Name SP AREA ***Place Name*** OGDEN
Location type
Surface
Survey purpose LOOKING FOR AN UNKNOWN PROBLEM

Pipe Use SANITAIRY SEWER	***Schedule length*** 150.0 ***Ft***	***From*** 38-WW4 ***Depth*** ***Ft***
Shape Circular	***Size*** 10 ***by*** ***ins***	***To*** 38A-WW4 ***Depth*** ***Ft***
Material CLAY	***Joint spacing*** 4.00 ***Ft***	***Direction*** Up
Lining CLAY	***Year laid***	***Pre-clean*** ***Last cleaned***

General note	Structural Service Constructional
Location note	Miscellaneous Hydraulic

Distance (Ft)	Description (Showing categories: Structural Service Constructional Miscellaneaous)	Media
150.0	38A-WW4 (Upstream. Depth = Ft) Tape end:	
5.2	Survey abandoned {DIRTY}	
0.0	Water level 0	
0.0	38-WW4 (Downstream. Depth = Ft) Tape start:0000	

Pipe Graphic Report of PLR 38-WW4 A for CH2M HILL

Works Order Number		***Cassette*** 1	***Surveyed On*** 12/22/2003	***Setup*** 2/3
Facility	***Operator*** TODD	***Van Reference*** 1	***Weather*** SNOW	

Road Name SP AREA ***Place Name*** OGDEN
Location type
Surface
Survey purpose LOOKING FOR AN UNKNOWN PROBLEM

Pipe Use SANITAIRY SEWER	***Schedule length*** 150.0 ***Ft***	***From*** 38-WW4 ***Depth*** ***Ft***
Shape Circular	***Size*** 10 ***by*** ***ins***	***To*** 38-WW3 ***Depth*** ***Ft***
Material CLAY	***Joint spacing*** 4.00 ***Ft***	***Direction*** Down
Lining CLAY	***Year laid***	***Pre-clean*** ***Last cleaned***

General note	Structural Service Constructional
Location note	Miscellaneaous Hydraulic

Distance (Ft)	Description (Showing categories: Structural Service Constructional Miscellaneaous)	Media
150.0	38-WW3 (Downstream. Depth = Ft) Tape end:	
150.0	Water level 0	
14.8	Survey abandoned [DIRTY]	
0.0	Water level 0	
0.0	38-WW4 (Upstream. Depth = Ft) Tape start:0000	

APPENDIX D
DNAPL DELINEATION REPORT

MEMORANDUM

THE FORRESTER GROUP
INSIGHTFUL ENVIRONMENTAL SOLUTIONS™

Date: October 20, 2003

To: File

From: Hoyt Sutphin

Subject: Ogden Railroad Facility
AOI-33
Additional DNAPL Zone Delineation

Copy to:

INTRODUCTION

As part of the remedial investigation for the Northern Area (OU-01), the zone of hydrocarbon DNAPL contamination associated with the former Pintsch Gas Works facility was delineated through the completion of 79 soil borings and the drilling and installation of 25 monitoring wells. The extent of the DNAPL zone as defined by the RI investigation is shown on Figure 2-11 of the RI report.[1]

Following submittal of the draft RI report, gaps were identified in the existing data; specifically, lack of subsurface data in the estimated area of the plume at the following locations;

- North of the Ogden River and west of the rail tracks,
- North of the 33-MW1FP DNAPL pool, and
- In the general area north of 33-MW2FP (approximate location of the former Pintsch Gas Works facility).

It was determined by the regulatory agencies that additional data was needed in these areas to support the subsequent remedial design and/or remedial action at the site[2].

In June 2003, a pilot geophysical survey was conducted over the DNAPL zone using electromagnetic soil conductivity instrumentation. The results proved unsuccessful and use of the geophysical instrument was severely limited by the apparent presence of buried and surface metal over much of the area. Variations in soil conductivity possibly associated with buried channels or depressions in the Alpine clay surface were masked by the instrument's response to the widespread background metal distribution. A summary report on the geophysical investigation was submitted to EPA in the June 2003 monthly progress report for the UPRR site.

The site investigation work plan for the field work described in this document was approved by EPA on September 2, after the number of proposed boring locations was revised to 34, from the original 20 boring locations included in initial the January 2003 work plan.

[1] Remedial Investigation Report - Part 2 - Final; Forrester Group, Arvada, CO, September 2003.

[2] EPA review Comments on DNAPL Delineation Work Plan, March 12, 2003; submitted to Gary Honeyman (UPRR) by Mario Robles (EPA).

INVESTIGATION OBJECTIVES & PROCEDURES

Based the data as presented in the RI Report (Part 2), the DNAPL occurs in structural depressions on top of the Alpine Clay. The main objective of the field investigation was to refine the interpretation of the Alpine clay surface and identify all low areas and preferential pathways where DNAPL could accumulate, with the goal of identifying target areas of the DNAPL zone that would need to be considered for DNAPL recovery under the remedial action alternatives evaluated in the Feasibility Study. A secondary objective was to fill the data gaps described above. Both objectives were met as a result of the investigation.

Additional DNAPL zone information was obtained through the completion of soil borings and observations of core during the field program conducted September 10th through the 15th. Thirty four additional borings were completed (Figure 1, boring locations 33-B85 to 33-B118). The work was conducted using Geoprobe direct push technology, with a dual-tube 5-foot coring system. Continuous core was retrieved in 5 foot lengths, beginning at 10 feet below the ground surface and continuing through the clay contact. Field observations made on each core to estimate the nature of DNAPL contamination include; (1) the presence of oil sheen, (2) degree of residual staining on gravels including occurrences of blebs or other evidence for the indication DNAPL in residual amounts, and (3) occurrence of potentially mobile DNAPL (i.e. soils with saturated pore spaces).

CONCLUSIONS OF ADDITIONAL DATA ANALYSIS

Logs of the completed borings are provided in Attachment 1. Attachment 2 contains representative photographs of core from the borings illustrating various degrees of DNAPL contamination. Boring completion information is summarized in Table 1, which includes the total depth of the boring, the depth below the ground surface and elevation of Alpine clay, and the vertical extent of DNAPL contamination observed in the core. The term "Residual Oil" in the four right hand columns in Table 1, refers to visual evidence of DNAPL in the soil, ranging from red staining to core saturation. It does not include intervals with only groundwater sheens.

Figure 1 shows the locations of all subsurface data for the DNAPL zone area. Locations shown in green are the September 2003 borings. The red isocontour lines show the interpreted elevation of the clay surface based on the previous elevation data (tables 2-3 and 3-1 of the RI Report Part 2) and the additional data contained in attached Table 1. In addition, the limit of the DNAPL zone (gray shaded area) was revised based on the September data. Revisions in the DNAPL zone characterization as compared to Figure 2-11 of the RI report (Part 2) are as follows:

1. Two small areas shown by 33-B90, 33-B103, and 33-B104 within the main body of the DNAPL zone do not have evidence of DNAPL contamination.

2. An approximate 15,000 square-foot area north of the Ogden River and west of the UPRR rail track does not appear to have evidence for DNAPL contamination. This area is identified by borings 33-B60, 33-B117, 33-B118, and 33-B114.

3. Minor revisions were made to the area of DNAPL zone adjacent to the east end of the 21st Street pond, based on re-contouring of the clay surface in that area.

Results of the re-contouring and observations of retrieved core show four low areas or depressions in the top of the Alpine Clay that may host accumulations of potentially mobile DNAPL that may be recoverable.

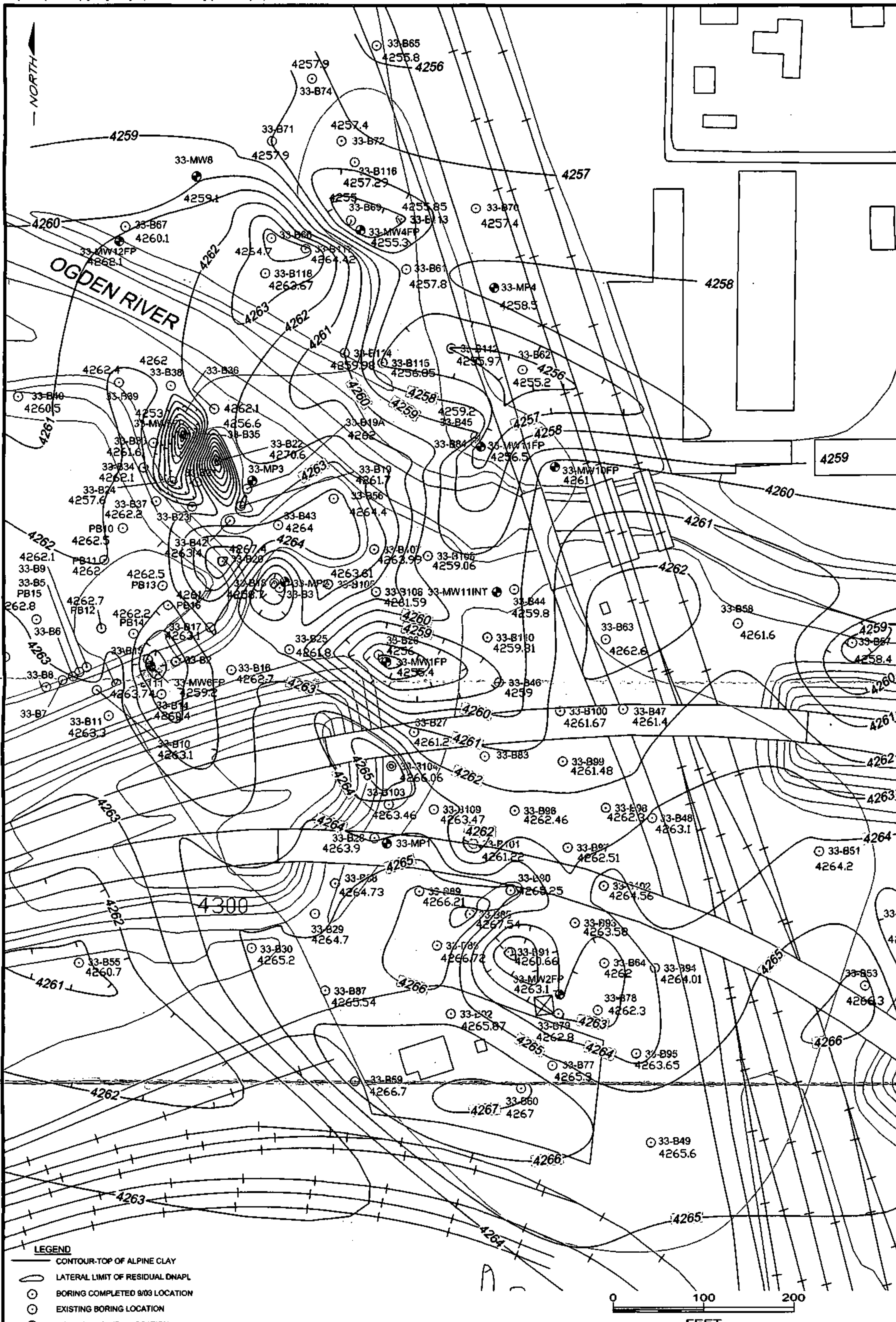
1. The largest is in the area of 33-MW1FP, where the pilot DNAPL recovery system removed over 1,400 gallons of DNAPL. Two 2 feet of DNAPL remain in the monitoring and recovery wells in this area. Another smaller depression exists 75 feet NW of the 33-MW1 area. This depression is represented by 33-B18 and 33-MP3, although 33-MP3 does not have any measurable DNAPL accumulation.

2. The second area is at the northern end of the DNAPL zone, north of the Ogden River. This depression is represented by borings 33-B69, 33-B113, and 33-MW4FP. 33-MW4FP does not have measurable accumulations of DNAPL, and had very limited indications of DNAPL contamination during drilling and installation. 33-B69 had DNAPL saturated gravels, as did 33-B113. An additional piezometer should be installed in the center of this depression to determine if mobile DNAPL is present.

3. The third area is near 33-MW2FP, which is in the vicinity of the former Pintsch Gas structure. Over 400 gallons of DNAPL were removed from the pilot test recovery well near 33-MW2FP. The operation of the pilot system appears to have depleted DNAPL in this area, as the pilot system observation wells and recovery well have not had measurable DNAPL accumulations since the end of the pilot test. A deeper area on top of the Alpine exists about 75 feet NW of 33-MW2FP, as defined by boring 33-B91. The clay elevation is about 2.5 feet lower at 33-B91. Although the observation of the core retrieved from this boring did not show clear evidence of potentially mobile DNAPL, it may have been limited by the poor core recovery. The proximity of the 33-MW2FP area and deeper gravel-clay contact make the occurrence of DNAPL in this depression likely. An additional piezometer should be installed in this depression to verify the presence or absence of mobile DNAPL.

4. The final area is the small depression identified by 33-MW5FP. This well appears to occur in a depression also identified by three other borings wit evidence of residual oil. Well 33-MW5FP contains less than 1 foot of DNAPL in the bottom of the well.

M:\clients\FORREST\Ogden\pintchgas\903CLAYAREA.dwg plotted: 10/22/2003



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APPROVED		

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UNION PACIFIC RAILROAD-OGDEN, UTAH

FIGURE 1

EXISTING BORINGS TO CLAY SURFACE

SCALE: 1"=100'

DWG. NO.: 903CLAYAREA.dwg

Table 1
21st Street Pond
Geoprobe Boring Data (33-B85 to 33-B118)

Boring ID	Boring Date	Northing	Easting	Ground Elevation (feet MSL)	Total Depth	Depth to Clay	Clay Elevation	Feet to Top of Residual Oil	Feet to Bottom of Residual Oil	Residual Oil Thickness	Elevation Top of Residual Oil
33-B85	9/10/2003	3608323.96	1506217.976	4283.04	19.0	15.5	4267.54	15.3	15.5	0.2	4267.74
33-B86	9/10/2003	3608289.47	1506181.573	4283.42	20.0	16.7	4266.72	16.1	16.7	0.6	4267.32
33-B87	9/10/2003	3608239.57	1506057.058	4285.04	20.0	19.5	4265.54	14.8	19.5	4.8	4270.29
33-B88	9/10/2003	3608358.21	1506067.845	4280.48	20.0	15.75	4264.73	13.5	15.8	2.3	4266.98
33-B89	9/10/2003	3608349.18	1506161.529	4282.46	20.0	16.25	4266.21	15.0	16.3	1.3	4267.46
33-B90	9/10/2003	360350.042	1506262.848	4282.75	20.0	17.5	4265.25	ND		0.0	
33-B91	9/10/2003	3608282.6	1506260.667	4285.06	25.0	24.4	4260.66	13.5	24.4	10.9	4271.56
33-B92	9/10/2003	3608213.86	1506196.795	4285.77	20.0	19.9	4265.87	13.4	19.9	6.5	4272.37
33-B93	9/11/2003	3608314.43	1506334.619	4284.83	25.0	21.25	4263.58	13.0	21.3	8.3	4271.83
33-B94	9/11/2003	3608264.93	1506423.283	4285.31	25.0	21.3	4264.01	12.8	21.3	8.6	4272.56
33-B95	9/11/2003	3608170.03	1506402.6	4285.75	25.0	22.1	4263.65	20.9	22.1	1.2	4264.85
33-B96	9/11/2003	3608438.07	1506267.243	4282.96	24.0	20.5	4262.46	18.8	20.5	1.7	4264.16
33-B97	9/11/2003	3608397.43	1506326.095	4283.76	23.5	21.25	4262.51	12.8	21.3	8.5	4271.01
33-B98	9/11/2003	3608440.92	1506368.581	4284.81	24.0	22.5	4262.31	13.4	22.5	9.1	4271.41
33-B99	9/11/2003	3608492.2	1506320.733	4283.98	24.5	22.5	4261.48	14.3	22.5	8.3	4269.73
33-B100	9/11/2003	3608547.82	1506317.709	4284.92	24.0	23.25	4261.67	21.8	23.3	1.5	4263.12
33-B101	9/11/2003	3608401.46	1506221.323	4282.42	23.5	21.2	4261.22	19.8	21.2	1.4	4262.62
33-B102	9/11/2003	3608354.98	1506366.321	4284.56	24.0	20	4264.56	14.0	20.0	6.0	4270.56
33-B103	9/12/2003	3608444.72	1506127.592	4278.46	15.0	15	4263.46	ND		0.0	
33-B104	9/12/2003	3608486.97	1506130.332	4278.36	15.0	12.3	4266.06	ND		0.0	
33-B105	9/12/2003	3608687.86	1506059.482	4278.11	15.0	14.5	4263.61	13.5	14.5	1.0	4264.61
33-B106	9/12/2003	3608679.51	1506112.878	4277.79	20.0	16.2	4261.59	15.0	16.2	1.2	4262.79
33-B107	9/12/2003	3608726.43	1506110.538	4277.59	15.0	13.6	4263.99	12.8	13.6	0.9	4264.84
33-B108	9/12/2003	3608719.19	1506170.358	4278.06	20.0	19	4259.06	18.2	19.0	0.8	4259.86
33-B109	9/12/2003	3608439.22	1506177.719	4283.27	20.0	19.8	4263.47	19.0	19.8	0.8	4264.27
33-B110	9/12/2003	3608629.14	1506236.611	4283.81	25.0	24	4259.81	17.0	24.0	7.0	4266.81
33-B111	9/15/2003	3608578.53	1505824.68	4279.49	20.0	15.75	4263.74	ND		0.0	
33-B112	9/15/2003	3608947.81	1506195.888	4283.57	29.0	27.6	4255.97	22.2	27.6	5.4	4261.37
33-B113	9/15/2003	3609091.6	1506139.744	4280.85	29.0	25	4255.85	17.7	25.0	7.3	4263.15
33-B114	9/15/2003	3608942.94	1506077.533	4278.18	20.0	18.2	4259.98	ND		0.0	
33-B115	9/15/2003	3608932.13	1506119.501	4279.45	25.0	22.6	4256.85	18.5	22.6	4.1	4260.95
33-B116	9/15/2003	3609154.9	1506088.36	4278.79	25.0	21.5	4257.29	19.3	21.5	2.2	4259.49
33-B117	9/15/2003	3609058.72	1506033.595	4280.17	20.0	15.75	4264.42	ND		0.0	
33-B118	9/15/2003	3609030.04	1505988.972	4279.67	20.0	16	4263.67	ND		0.0	

ATTACHMENT 1

BORING LOGS

CH2MHILL

PROJECT NUMBER: 170169.01.43	BORING NUMBER: 33-B85	SHEET 1 OF 1

SOIL BORING LOG

PROJECT: UPRR | START: 9/10/2003 | FINISH: 9/10/2003
LOCATION: OU-1 | AREA: Northern Area | LOGGER: Terence Mares & Aaron Galer
DRILLING SUBCONTRACTOR: EarthProbe | DRILLING METHOD AND EQUIPMENT: Track-mounted Geoprobe & 5 ft Macro-Core sampler

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
		5	SP	Sand - poorly sorted, with gravel, dry, loose, and no odor	
5		5	ML	Silt - sandy, reddish brown, low plasticity, medium dense, dry, no odor -- Sand lense from 8' to 8.2'	
10		2.5			
			SW	12.5' - Sand - poorly sorted, greyish brown, water saturated, medium grained	
15	I Residual		GM	15.3 - 15.5' - Gravel - silty with sand, HC odor, residual HC	
		3.7	MH	Clay - Silty, high plasticity, very soft, grey	
20				Top of residual HC at 15.3' Top of clay at 15.5' Total depth 19' Hole plugged with Bentonite Depth to water at 12.5' Picture # 20	

CH2MHILL

PROJECT NUMBER:	170169.01.43	BORING NUMBER:	33-B86	SHEET 1 OF 1

SOIL BORING LOG

PROJECT: UPRR
START: 9/10/2003
FINISH: 9/10/2003
LOCATION: OU-1
AREA: Northern Area
LOGGER: Terence Mares & Aaron Galer
DRILLING SUBCONTRACTOR: EarthProbe
DRILLING METHOD AND EQUIPMENT: Track-mounted Geoprobe & 5 ft Macro-Core sampler

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
		2.7	GM	12.7' - Gravel - silty with sand, loose, saturated ~ 13.3' - HC sheen	
15	Sheen		ML	Silty - sandy, grayish brown, HC odor, low plasticity	
	Residual		GM	16.1' - Gravel - silty with sand, loose, saturated, strong HC odor, residual HC	
		4.6	MH	16.7' - Silty - clay, grayis brown, high plasticity	
20					
25				Top of HC sheen at 13.3' Top of residual/mobile at 16.1' Top of clay at 16.7' Total depth 20' Hole plugged with Bentonite Pictures # 21, 22, 23	

PROJECT NUMBER: 170169.01.43	BORING NUMBER: 33-B87	SHEET 1 OF 1

CH2MHILL

SOIL BORING LOG

PROJECT: UPRR START: 9/10/2003 FINISH: 9/10/2003
LOCATION: OU-1 AREA: Northern Area LOGGER: Terence Mares & Aaron Geler
DRILLING SUBCONTRACTOR: EarthProbe DRILLING METHOD AND EQUIPMENT: Track-mounted Geoprobe & 5 ft Macro-Core sampler

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
		2.5	GM	12.5' - Gravel - silty with sand, loose, saturated	
15		sheen		– 14.6' - HC sheen – 14.75' - HC residual	
		stain 1.75 Residual			
20			MH	19.5' - Silty - clayey	
25				Top of HC sheen at 14.6' Top of residual at 14.75' Top of clay at 19.5' Total depth 20' Hole plugged with Bentonite No Picture	

CH2MHILL

PROJECT NUMBER: 170169.01.43 **BORING NUMBER:** 33-B88 **SHEET** 1 **OF** 1

SOIL BORING LOG

PROJECT: UPRR **START:** 9/10/2003 **FINISH:** 9/10/2003
LOCATION: OU-1 **AREA:** Northern Area **LOGGER:** Terence Mares & Aaron Gater
DRILLING SUBCONTRACTOR: EarthProbe **DRILLING METHOD AND EQUIPMENT:** Track-mounted Geoprobe & 5 ft Macro-Core sampler

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Sheen	3.0	GM	12' - Gravel - silty with sand, loose, saturated – 12.7' - HC sheen – 13.5' - HC residual	
15	Residual			– 15.2' - Residual HC with sheen	
		5	MH	15.75' - Silty - clayey	
20					
25				Top of HC sheen at 12.7' Top of residual HC at 13.5' Top of clay at 15.75' Total depth 20' Hole plugged with Bentonite Pictures # 24, 25	

CH2MHILL

PROJECT NUMBER: 170169.01.43	BORING NUMBER: 33-B89	SHEET 1 OF 1

SOIL BORING LOG

PROJECT: UPRR START: 9/10/2003 FINISH: 9/10/2003
LOCATION: OU-1 AREA: Northern Area LOGGER: Terence Mares & Aaron Gafer
DRILLING SUBCONTRACTOR: EarthProbe DRILLING METHOD AND EQUIPMENT: Track-mounted Geoprobe & 5 ft Macro-Core sampler

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
		1			
15	Sheen / Residual		GM	14' - Gravel - silty with sand, loose, saturated, slight HC odor – 14' - HC sheen – 15' - Residual HC	Fist try between 15 and 20' no recovery Pushed tip down to move rock tried again between 21 and 24' for sample. Moved hole 3.5' and start sampling at 15'.
		5	MH	16.25' - Silty - clayey	
20					
25				Top of HC sheen at 14' Top of residual HC at 15' Top of clay at 16.25' Total depth 20' Hole plugged with Bentonite No pictures	

CH2MHILL

PROJECT NUMBER: 170169.01.43	BORING NUMBER: 33-B90	SHEET 1 OF 1

SOIL BORING LOG

PROJECT: UPRR
START: 9/10/2003
FINISH: 9/10/2003
LOCATION: OU-1
AREA: Northern Area
LOGGER: Terence Mares & Aaron Galer
DRILLING SUBCONTRACTOR: EarthProbe
DRILLING METHOD AND EQUIPMENT: Track-mounted Geoprobe & 5 ft Macro-Core sampler

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
		2.6	GM	12.5' - Gravel - silty with sand, loose, saturated, no odor, no HC sheen	
15		3			
			MH	Silty - clayey	
20					
25				Top of clay at 17.5' Total depth 20' Hole plugged with Bentonite No pictures	

CH2MHILL

PROJECT NUMBER: 170169.01.43	BORING NUMBER: 33-B91	SHEET 1 OF 1

SOIL BORING LOG

PROJECT: UPRR START: 9/10/2003 FINISH: 9/10/2003
LOCATION: OU-1 AREA: Northern Area LOGGER: Terence Mares & Aaron Gater
DRILLING SUBCONTRACTOR: EarthProbe DRILLING METHOD AND EQUIPMENT: Track-mounted Geoprobe & 5 ft Macro-Core sampler

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
		1.5			
			GM	13.5' - Gravel - silty with sand, strong HC odor, start of HC residual	
15	staining	1.75		-- HC residual through out sample	
20	Residual	1.7		-- HC residual through out sample	
25			MH	24.4' - Silty - clayey	
				Top of residual HC at 13.5' Top of clay at 24.4' Total depth 25' Hole plugged with Bentonite No pictures	

CH2MHILL

PROJECT NUMBER: 170169.01.43	BORING NUMBER: 33-B92	SHEET 1 OF 1

SOIL BORING LOG

PROJECT: UPRR
START: 9/10/2003
FINISH: 9/10/2003
LOCATION: OU-1
AREA: Northern Area
LOGGER: Terence Mares & Aaron Galer
DRILLING SUBCONTRACTOR: EarthProbe
DRILLING METHOD AND EQUIPMENT: Track-mounted Geoprobe & 5 ft Macro-Core sampler

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
		2			
	sheen		GM	13' - Gravel - silty with sand, HC odor, start of HC sheen – 13.4' - HC residual	
15					
	Residual				
		2.3		– 17.6' - Mobile HC oozing from sediment just like 33-B85	
	saturated?				
20			MH	19.9' - Silty - clayey	
25				Top of HC sheen at 13' Top of residual HC at 13.4' Top of mobile HC at 17.6' Top of clay at 19.9' Total depth 20' Hole plugged with Bentonite Pictures # 26, 27	

CH2MHILL

PROJECT NUMBER: 170169.01.43	BORING NUMBER: 33-B93	SHEET 1 OF 1

SOIL BORING LOG

PROJECT: UPRR START: 9/11/2003 FINISH: 9/11/2003
LOCATION: OU-1 AREA: Northern Area LOGGER: Terence Mares & Aaron Galer
DRILLING SUBCONTRACTOR: EarthProbe DRILLING METHOD AND EQUIPMENT: Track-mounted Geoprobe & 5 ft Macro-Core sampler

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	sheen; staining	2.2	GM	12.2' - Gravel - silty with sand, slight HC odor ~ 12.8' - HC sheen ~ 13' - Residual HC	
15		2			
20		5	MH	21.25' - Silty - clayey	
25				Top of HC sheen at 12.8' Top of residual HC at 13' Top of clay at 21.25' Total depth 25' Hole plugged with Bentonite Pictures # 28	

CH2MHILL

PROJECT NUMBER:	170169.01.43	BORING NUMBER:	33-B94	SHEET 1 OF 1

SOIL BORING LOG

PROJECT: UPRR **START:** 9/11/2003 **FINISH:** 9/11/2003
LOCATION: OU-1 **AREA:** Northern Area **LOGGER:** Terence Mares & Aaron Galer
DRILLING SUBCONTRACTOR: EarthProbe **DRILLING METHOD AND EQUIPMENT:** Track-mounted Geoprobe & 5 ft Macro-Core sampler

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	stain / Residual / sheen	3.25	ML	Silty - sand, low plasticity, saturated, grayish brown -- 11.5' HC sheen	
			GM	12.5' - Gravel - silty with sand and strong HC odor -- 12.75' residual HC	
15		2.5		-- 19' potentially mobile HC	
20	saturated	5			
			MH	21.3' - Silty - clayey	
25					
				Top of HC sheen at 11.5' Top of residual HC at 12.75' Top of potentially mobile HC at 19' Top of clay at 21.3' Total depth 25' Hole plugged with Bentonite No pictures	

CH2MHILL

PROJECT NUMBER: 170169.01.43	BORING NUMBER: 33-B95	SHEET 1 OF 1

SOIL BORING LOG

PROJECT: UPRR START: 9/11/2003 FINISH: 9/11/2003
LOCATION: OU-1 AREA: Northern Area LOGGER: Terence Mares & Aaron Galer
DRILLING SUBCONTRACTOR: EarthProbe DRILLING METHOD AND EQUIPMENT: Track-mounted Geoprobe & 5 ft Macro-Core sampler

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
		3.6	ML	Silty - sand, low plasticity, saturated, grayish brown	
15	Sheen	2.75	GM	14.1' - Gravel - silty with sand, HC odor, start of HC sheen	
20	Residual	5		– 20.9' residual HC	
25			MH	22.1' - Silty - clayey	
				Top of HC sheen at 14.1' Top of residual HC at 20.9' Top of clay at 22.1' Total depth 25' Hole plugged with Bentonite Pictures # 30, 31, 32	

CH2MHILL

PROJECT NUMBER:	170169.01.43	BORING NUMBER:	33-B96	SHEET 1 OF 1

SOIL BORING LOG

PROJECT: UPRR | START: 9/11/2003 | FINISH: 9/11/2003
LOCATION: OU-1 | AREA: Northern Area | LOGGER: Terence Mares & Aaron Galer
DRILLING SUBCONTRACTOR: EarthProbe | DRILLING METHOD AND EQUIPMENT: Track-mounted Geoprobe & 5 ft Macro-Core sampler

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
		2.8	SP	Sand - with gravel, homogeneous, fine grained, loose, dry, black stained, no odor	
5			ML	4.3' - Silty - sand, low plasticity, moist, black, and soft	
		3.7			
10			GM	9.3' - Gravel - fine to coarse sand, fine to coarse gravel, loose, saturated start of HC sheen	
	sheen	1.1			
15		2.6			
	m			– 18.8' to 20' mobile HC	
20	R			– 20' to 20.5' residual HC	
	m			– 20.5' to top of clay with potentially mobile HC	
		4	MH	Silty - clayey	
25				Top of HC sheen at 9.3' Residual HC from 20 to 20.5' Mobile HC from 18.8 to 20' then from 20.5 to 21' Top of clay at 21' Depth to water 6.25' Total depth 24' Hole plugged with Bentonite Pictures # 33, 34, 35	

CH2MHILL	PROJECT NUMBER: 170169.01.43	BORING NUMBER: 33-B97	SHEET 1 OF 1
	SOIL BORING LOG		

PROJECT: UPRR START: 9/11/2003 FINISH: 9/11/2003
LOCATION: OU-1 AREA: Northern Area LOGGER: Terence Mares & Aaron Galer
DRILLING SUBCONTRACTOR: EarthProbe DRILLING METHOD AND EQUIPMENT: Track-mounted Geoprobe & 5 ft Macro-Core sampler

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	sheen	3.1	GM	Gravel - silty with sand, loose, saturated, HC odor – 11.9' HC sheen – 12.75 to 12.9' globlets of HC	
15	stain & Residual	0		– Little bit of gravel with sand and fines at tip of sampler. Tip has HC sheen.	
20		2.5	MH	21.25' - Silty - clayey	
25				Top of HC sheen at 11.9' Globlets of HC from 12.75 to 12.9' Top of clay at 21.25' Total depth 23.5' Hole plugged with Bentonite No pictures	

CH2MHILL

PROJECT NUMBER:	170169.01.43	BORING NUMBER:	33-B98	SHEET 1 OF 1

SOIL BORING LOG

PROJECT: UPRR START: 9/11/2003 FINISH: 9/11/2003
LOCATION: OU-1 AREA: Northern Area LOGGER: Terence Mares & Aaron Galer
DRILLING SUBCONTRACTOR: EarthProbe DRILLING METHOD AND EQUIPMENT: Track-mounted Geoprobe & 5 ft Macro-Core sampler

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
		2.75	GM	Gravel - silty with sand, loose, saturated, slight HC odor -- 13.4' to 13.6' globlets of HC -- 14.5 to 14.7' globlets of HC	
15	Residual & sheen	2.2		-- 17.6' HC sheen -- 19.25' globlets of HC for 2"	
20	potential	1.7		-- 21.2' residual HC -- 21.7 Potentially mobile oil	
			MH	22.5' - Silty - clayey	
25				Top of HC sheen at 17.6' Top of residual HC at 22.5' Top of potentially mobile HC at 23' Total depth 24' Hole plugged with Bentonite Pictures # 36 -- Rock stuck in shoe sleeve. Driller stated pushing became soft at 22.5'	

CH2MHILL

PROJECT NUMBER: 170169.01.43 | **BORING NUMBER:** 33-B99 | **SHEET** 1 **OF** 1

SOIL BORING LOG

PROJECT: UPRR **START:** 9/11/2003 **FINISH:** 9/11/2003
LOCATION: OU-1 **AREA:** Northern Area **LOGGER:** Terence Mares & Aaron Galer
DRILLING SUBCONTRACTOR: EarthProbe **DRILLING METHOD AND EQUIPMENT:** Track-mounted Geoprobe & 5 ft Macro-Core sampler

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
			ML	Silt - clayey, saturated, no odor	
		5	GM	10.5' - Gravel - silty with sand, loose, and saturated – 14.25 to 14.5' globlets of HC	
15		2.6		– 17.4' globlets of HC for 2" – 19.4' HC sheen	
20		4.5	SP	21.2' - Sand - poorly sorted, grayish brown, loose, HC odor	
			GM	22.2' - Gravel - silty with sand, loose, saturated, start of residual HC	
			MH	22.5' Silty - clayey	
25				Top of HC sheen at 19.4' Top of residual HC at 22.2' Top of clay at 22.5' Total depth 24.5' Hole plugged with Bentonite No pictures	

Sheen / Residual

Residual

CH2MHILL

PROJECT NUMBER:	170169.01.43	BORING NUMBER:	33-B100	SHEET 1 OF 1

SOIL BORING LOG

PROJECT: UPRR START: 9/11/2003 FINISH: 9/11/2003
LOCATION: OU-1 AREA: Northern Area LOGGER: Terence Mares & Aaron Galer
DRILLING SUBCONTRACTOR: EarthProbe DRILLING METHOD AND EQUIPMENT: Track-mounted Geoprobe & 5 ft Macro-Core sampler

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
		3	SP/CL	Sand/Clay - with well rounded gravel, low plasticity, saturated, brown	
15		1.8			
		sheen & Residual	GM	18.2' - Gravel - fine to coarse sand, loose, saturated – 19.6' HC sheen	
20		2.2		– 21.8' residual HC – 22 to 22.75' potentially mobile HC – 22.75 to top of clay residual HC	
		pooled	MH	23.25' - Silty - clayey	
25				Top of HC sheen at 19.6' Top of residual HC at 21.8' and from 22.75 to 23.25' Potentially mobile HC from 22 to 22.75' Top of clay at 23.25' Total depth 24' Hole plugged with Bentonite No pictures	

CH2MHILL

PROJECT NUMBER:	170169.01.43	BORING NUMBER:	33-B101	SHEET 1 OF 1

SOIL BORING LOG

PROJECT: UPRR START: 9/11/2003 FINISH: 9/11/2003
LOCATION: OU-1 AREA: Northern Area LOGGER: Terence Mares & Aaron Galer
DRILLING SUBCONTRACTOR: EarthProbe DRILLING METHOD AND EQUIPMENT: Track-mounted Geoprobe & 5 ft Macro-Core sampler

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
		1.75	GM	Gravel - fine to coarse sand, loose, saturated, no HC odor ~ 19.6' HC sheen	
15					
	sheen	1.9	ML	18.1' - Silty - sand, high plasticity, saturated, ~ 18.5' HC sheen ~ 19.8' Potentially mobile HC	
20	mobile	2.7	MH	21.2'- Silty - Clayey	
25				Top of HC sheen at 18.5' Top of potentially mobile HC at 19.8' Top of clay at 21.2' Total depth 23.5' Hole plugged with Bentonite Pictures # 37 of soil and # 38 and 39 of EarthProbe workers	

CH2MHILL	PROJECT NUMBER: 170169.01.43	BORING NUMBER: 33-B102	SHEET 1 OF 1

SOIL BORING LOG

PROJECT: UPRR START: 9/11/2003 FINISH: 9/11/2003
LOCATION: OU-1 AREA: Northern Area LOGGER: Terence Mares & Aaron Galer
DRILLING SUBCONTRACTOR: EarthProbe DRILLING METHOD AND EQUIPMENT: Track-mounted Geoprobe & 5 ft Macro-Core sampler

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
		4.1	SP/CL	Sand/Clay - layered with fine grained sand and well rounded gravel, high plasticity, saturated – 14 to 14.25' globlets of HC	
15	sheen	2		– 18' HC sheen	
20		4	MH	20'- Silty - Clayey	
25				Top of HC sheen at 18' Top of clay at 20' Total depth 24' Hole plugged with Bentonite No pictures	

CH2MHILL

PROJECT NUMBER: 170169.01.43	BORING NUMBER: 33-B103	SHEET 1 OF 1

SOIL BORING LOG

PROJECT: UPRR | START: 9/12/2003 | FINISH: 9/12/2003
LOCATION: OU-1 | AREA: Northern Area | LOGGER: Terence Mares & Aaron Galer
DRILLING SUBCONTRACTOR: EarthProbe | DRILLING METHOD AND EQUIPMENT: Track-mounted Geoprobe & 5 ft Macro-Core sampler

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
		1.25	GM	Gravel - silty with sand, No HC odor, No sheen, saturated	
15				Silty - clayey material in bottom of shoe at 15' Top of clay at 15' Total depth 15' Hole plugged with Bentonite No pictures	
20					
25					

CH2MHILL

PROJECT NUMBER: 170169.01.43	BORING NUMBER: 33-B104	SHEET 1 OF 1

SOIL BORING LOG

PROJECT: UPRR
START: 9/12/2003
FINISH: 9/12/2003
LOCATION: OU-1
AREA: Northern Area
LOGGER: Terence Mares & Aaron Galer
DRILLING SUBCONTRACTOR: EarthProbe
DRILLING METHOD AND EQUIPMENT: Track-mounted Geoprobe & 5 ft Macro-Core sampler

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
		4.25	GM	Gravel - silty with sand, No HC odor, No sheen, saturated	
			MH	12.3' - Silty - clayey	
15					
				Top of clay at 12.3' Total depth 15' Hole plugged with Bentonite No pictures	
20					
25					

CH2MHILL

PROJECT NUMBER: 170169.01.43	BORING NUMBER: 33-B105	SHEET 1 OF 1

SOIL BORING LOG

PROJECT: UPRR START: 9/12/2003 FINISH: 9/12/2003
LOCATION: OU-1 AREA: Northern Area LOGGER: Terence Mares & Aaron Galer
DRILLING SUBCONTRACTOR: EarthProbe DRILLING METHOD AND EQUIPMENT: Track-mounted Geoprobe & 5 ft Macro-Core sampler

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	sheen	2.5	GM	Gravel - silty with sand, HC odor,saturated, loose – 12.5' HC sheen – 13.5' residual HC	
15			MH	14.5' - Silty - clayey	
	Residual			– Sampler stuck. Drillers had to yank out tube, which may have moved soil sample inside the tube.	
20					
25				Top of HC sheen at 12.5' Top of residual HC at 13.5' Top of clay at 14.5' Total depth 15' Hole plugged with Bentonite Pictures # 58 - 62	

CH2MHILL	PROJECT NUMBER: 170169.01.43	BORING NUMBER: 33-B106	SHEET 1 OF 1
	SOIL BORING LOG		

PROJECT: UPRR **START:** 9/12/2003 **FINISH:** 9/12/2003
LOCATION: OU-1 **AREA:** Northern Area **LOGGER:** Terence Mares & Aaron Galer
DRILLING SUBCONTRACTOR: EarthProbe **DRILLING METHOD AND EQUIPMENT:** Track-mounted Geoprobe & 5 ft Macro-Core sampler

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
0–5		3.4	SM	Silty - sands, low plasticity, moist, brown	
5–10		2.5	SP	4.3' - Sand - medium grained, uniformly sorted, grayish brown, loose	
			GM	7.5' - Gravel - silty with sand, saturated, loose	
10–15	Sheen	1.75		– 14.8' HC sheen – 15 to 15.75' potentially mobile HC – 15.75' to top of clay residual HC	
15–20	Residual	5	MH	16.2' - Silty - clayey	
				Top of HC sheen at 14.8' Residual HC from 15.75 to 16.2' Potentially mobile HC from 15 to 15.75' Top of clay at 16.2' Total depth 20' Hole plugged with Bentonite Pictures # 63, 64, 65	

CH2MHILL

PROJECT NUMBER: 170169.01.43	BORING NUMBER: 33-B107	SHEET 1 OF 1

SOIL BORING LOG

PROJECT: UPRR
START: 9/12/2003
FINISH: 9/12/2003
LOCATION: OU-1
AREA: Northern Area
LOGGER: Terence Mares & Aaron Gafer
DRILLING SUBCONTRACTOR: EarthProbe
DRILLING METHOD AND EQUIPMENT: Track-mounted Geoprobe & 5 ft Macro-Core sampler

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
		Residual	SP	Sand - poorly sorted, with gravel, loose	
		4	GM	12.75' - Gravel - silty with sand, HC odor, saturated, loose, start of HC sheen	
			MH	Silty - clayey	
15					
20				Top of HC sheen at 12.75' Residual HC from 12.75 to 13.1' Top of clay at 13.6' Total depth 15' Hole plugged with Bentonite Pictures # 66	
25					

PROJECT NUMBER: 170169.01.43	BORING NUMBER: 33-B108	SHEET 1 OF 1

CH2MHILL

SOIL BORING LOG

PROJECT: UPRR START: 9/12/2003 FINISH: 9/12/2003
LOCATION: OU-1 AREA: Northern Area LOGGER: Terence Mares & Aaron Galer
DRILLING SUBCONTRACTOR: EarthProbe DRILLING METHOD AND EQUIPMENT: Track-mounted Geoprobe & 5 ft Macro-Core sampler

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
		2.2	GM	Gravel - silty with sand, HC odor, saturated, loose, start of HC sheen	
15					
	Residual sheen	2.4		-- 17.6' HC sheen -- 18.2' residual HC -- 18.5' potentially mobile HC	
			MH	19' - Silty - clayey	
20					
				-- Rock stuck in shoe. EarthProbe driller stated pushing became soft at 19'. Only 2" of clay inside sleeve.	
25					

Top of HC sheen at 17.6'
Top of residual HC at 18.2'
Top of potentially mobile HC at 18.5'
Top of clay at 19'
Total depth 20'
Hole plugged with Bentonite
No pictures

CH2MHILL

PROJECT NUMBER:	170169.01.43	BORING NUMBER:	33-B109	SHEET 1 OF 1

SOIL BORING LOG

PROJECT: UPRR
START: 9/12/2003
FINISH: 9/12/2003
LOCATION: OU-1
AREA: Northern Area
LOGGER: Terence Mares & Aaron Galer
DRILLING SUBCONTRACTOR: EarthProbe
DRILLING METHOD AND EQUIPMENT: Track-mounted Geoprobe & 5 ft Macro-Core sampler

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
		5	GM	Gravel - silty with sand, saturated, loose	
15					
		sheen 5		– 18.4' HC sheen – 19' residual HC – 19.3' potentially mobile HC	
20			MH	19.8' - Silty - clayey	
25				Top of HC sheen at 18.4' Top of residual HC at 19' Top of potentially mobile HC at 19.3' Top of clay at 19.8' Total depth 20' Hole plugged with Bentonite Pictures # 67	

CH2MHILL

PROJECT NUMBER: 170169.01.43	BORING NUMBER: 33-B110	SHEET 1 OF 1

SOIL BORING LOG

PROJECT: UPRR | START: 9/12/2003 | FINISH: 9/12/2003
LOCATION: OU-1 | AREA: Northern Area | LOGGER: Terence Mares & Aaron Galer
DRILLING SUBCONTRACTOR: EarthProbe | DRILLING METHOD AND EQUIPMENT: Track-mounted Geoprobe & 5 ft Macro-Core sampler

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
		2.9	GM	Gravel - silty with sand, saturated, loose	
15			SM	14' - Silty - sands, low plasticity, moist, brown	
		1.6	GM	16.4' - Gravel - silty with sand, saturated, loose – 17 to 15.4' globlets of HC – 18' residual HC	Drilling became dense at 18' tried to push down farther but could not. Went back down for sample between 15 and 20' no recovery.
	sheen	0			
20	stain & sheen	1.3		– 22.9' potentially mobile HC	
	saturated				
25			MH	24' - Silty - clayey	
				– Clay measured in sampler sleeve. However, EarthProbe driller stated rocks are plugging hole and feels clay at 24'.	

Top of potentially mobile HC at 22.9'
Top of clay at 24' – Per EarthProbe driller
Total depth 25'
Hole plugged with Bentonite
No pictures

CH2MHILL

PROJECT NUMBER: 170169.01.43 | BORING NUMBER: 33-B111 | SHEET 1 OF 1

SOIL BORING LOG

PROJECT: UPRR START: 9/15/2003 FINISH: 9/15/2003
LOCATION: OU-1 AREA: Northern Area LOGGER: Aaron Galer
DRILLING SUBCONTRACTOR: EarthProbe DRILLING METHOD AND EQUIPMENT: Track-mounted Geoprobe & 5 ft Macro-Core sampler

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
15	sheen	2	GM	Gravel - silty with sand, saturated, loose – 14' HC sheen	
20		5	MH	15.75' - Silty - Clayey	
25				Top of HC sheen at 14' Top of clay at 15.75' Total depth 20' Hole plugged with Bentonite No Pictures	

CH2MHILL	PROJECT NUMBER: 170169.01.43	BORING NUMBER: 33-B112	SHEET 1 OF 1
	SOIL BORING LOG		

PROJECT: UPRR START: 9/15/2003 FINISH: 9/15/2003
LOCATION: OU-1 AREA: Northern Area LOGGER: Aaron Galer
DRILLING SUBCONTRACTOR: EarthProbe DRILLING METHOD AND EQUIPMENT: Track-mounted Geoprobe & 5 ft Macro-Core sampler

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
		2.3	GM	Gravel - silty with sand, saturated, loose	
15		2			
20		3		-- 22' HC sheen -- 22.2 to 23.2' potentially mobile HC -- 23.2 to 23.7' residual HC	
		sheen Residual oil			
25		4		-- 25.4 to top of clay, potentially mobile HC	
		oil saturated	MH	27.6' - Silty - Clayey	
30				Top of HC sheen at 22' Residual HC from 23.2 to 23.7' Potentially mobile HC from 22.2 to 23.2' and 25.4 to 27.6' Top of clay at 27.6' Total depth 29' Hole plugged with Bentonite Pictures # 38 - 42	

CH2MHILL

PROJECT NUMBER: 170169.01.43 **BORING NUMBER:** 33-B113 **SHEET** 1 **OF** 1

SOIL BORING LOG

PROJECT: UPRR **START:** 9/15/2003 **FINISH:** 9/15/2003
LOCATION: OU-1 **AREA:** Northern Area **LOGGER:** Aaron Galer
DRILLING SUBCONTRACTOR: EarthProbe **DRILLING METHOD AND EQUIPMENT:** Track-mounted Geoprobe & 5 ft Macro-Core sampler

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
		.9	GM	Gravel - silty with sand, saturated, loose	
15	Residual oil	2.3		-- 17.7' residual HC -- 18.3 to 20' potentially mobile HC	
20	oil saturated	1.6		-- 23.4 to 25' potentially mobile HC	
25		4	MH	-- 100% clay in last sampling sleeve with gravel intermixed at top (25').	
30				Top of residual HC at 17.7' Potentially mobile HC from 18.3 to 20' and 23.4 to 25' Top of clay at 25' Total depth 29' Hole plugged with Bentonite Pictures # 43, 44, 45	

CH2MHILL	PROJECT NUMBER: 170169.01.43	BORING NUMBER: 33-B114	SHEET 1 OF 1

SOIL BORING LOG

PROJECT: UPRR | START: 9/15/2003 | FINISH: 9/15/2003

LOCATION: OU-1 | AREA: Northern Area | LOGGER: Aaron Galer

DRILLING SUBCONTRACTOR: EarthProbe | DRILLING METHOD AND EQUIPMENT: Track-mounted Geoprobe & 5 ft Macro-Core sampler

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
		2.9	SM	Silty - sands, low plasticity, moist, brown, no odor	
			GM	3.8' - Gravel - silty with sand, saturated, loose, no sheen, no odor	
5		2.7			
10		2.3			
15		3.75			
			MH	18.2' - Silty - Clayey	
20				Top of clay at 18.2' Total depth 20' Hole plugged with Bentonite Pictures # 24, 25	

CH2MHILL

PROJECT NUMBER: 170169.01.43	BORING NUMBER: 33-B115	SHEET 1 OF 1

SOIL BORING LOG

PROJECT: UPRR
LOCATION: OU-1
DRILLING SUBCONTRACTOR: EarthProbe
START: 9/15/2003
FINISH: 9/15/2003
AREA: Northern Area
LOGGER: Terence Mares & Aaron Galer
DRILLING METHOD AND EQUIPMENT: Track-mounted Geoprobe & 5 ft Macro-Core sampler

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
		1.8	GM	Gravel - silty with sand, saturated, loose – 13.7' HC sheen with globlets – 14' HC sheen	
15	sheen	2.4		– 18' HC sheen reappears – 18.5' residual or mobile HC	
20	Residual oil	2.8		– HC sheen with globlets just above clay layer	
			MH	22.6' - Silty - Clayey	
25				Top of HC sheen at 13.7' Top of residual or mobile HC at 18.5' Top of clay at 22.6' Total depth 25' Hole plugged with Bentonite Pictures # 46	

CH2MHILL	PROJECT NUMBER: 170169.01.43	BORING NUMBER: 33-B116	SHEET 1 OF 1
	SOIL BORING LOG		

PROJECT: UPRR
LOCATION: OU-1
DRILLING SUBCONTRACTOR: EarthProbe
START: 9/15/2003
FINISH: 9/15/2003
AREA: Northern Area
LOGGER: Aaron Galer
DRILLING METHOD AND EQUIPMENT: Track-mounted Geoprobe & 5 ft Macro-Core sampler

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
		1.6	GM	Gravel - silty with sand, saturated, loose ~ 19.3' potentially mobile HC	
20	Residual	pooled oil			
		4.9	MH	21.5' - Silty - Clayey	
25					
				~ Top 33" of casing heavily covered in HC. Although no sign of mobile HC above clay in this cone. Top of potentially mobile HC at 19.3' Top of clay at 21.5' Total depth 25' Hole plugged with Bentonite Pictures # 47, 48	

CH2MHILL

PROJECT NUMBER: 170169.01.43	BORING NUMBER: 33-B117	SHEET 1 OF 1

SOIL BORING LOG

PROJECT: UPRR
START: 9/15/2003
FINISH: 9/15/2003
LOCATION: OU-1
AREA: Northern Area
LOGGER: Aaron Galer
DRILLING SUBCONTRACTOR: EarthProbe
DRILLING METHOD AND EQUIPMENT: Track-mounted Geoprobe & 5 ft Macro-Core sampler

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
		5	GM	Gravel - silty with sand, saturated, loose, no odor, no sheen	
			MH	15.75' - Silty - Clayey	
20					
				Top of clay at 15.75' Total depth 20' Hole plugged with Bentonite No pictures	
25					
25					

CH2MHILL

PROJECT NUMBER:	170169.01.43	BORING NUMBER:	33-B118	SHEET 1 OF 1

SOIL BORING LOG

PROJECT: UPRR START: 9/15/2003 FINISH: 9/15/2003
LOCATION: OU-1 AREA: Northern Area LOGGER: Terence Mares & Aaron Galer
DRILLING SUBCONTRACTOR: EarthProbe DRILLING METHOD AND EQUIPMENT: Track-mounted Geoprobe & 5 ft Macro-Core sampler

Depth Below Surface (ft)	SAMPLE INTERVAL	RECOVERY (ft)	USCS CODE	SOIL NAME, USCS GROUP SYMBOL, COLOR MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
15		2	GM	Gravel - silty with sand, saturated, loose, no odor, no sheen	
20		5	MH	16' - Silty - Clayey	
25				Top of clay at 16' Total depth 20' Hole plugged with Bentonite No pictures	

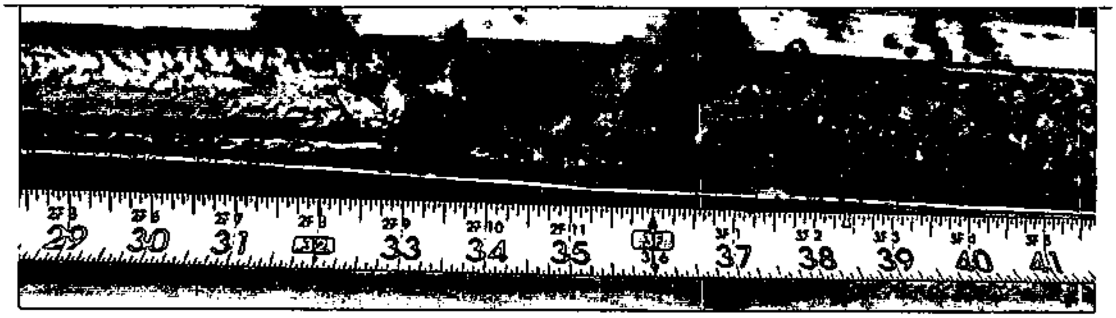
ATTACHMENT 2

FIELD PHOTOGRAPHS

Color Photo(s)

The following pages contain color that does not appear in the scanned images.

To view the actual images, please contact the Superfund Records Center at (303) 312-6473.



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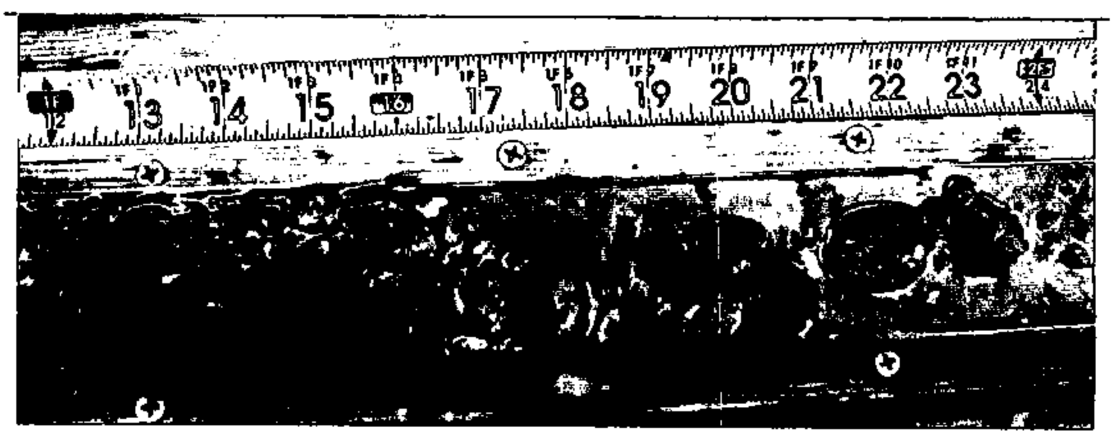
33-B86c



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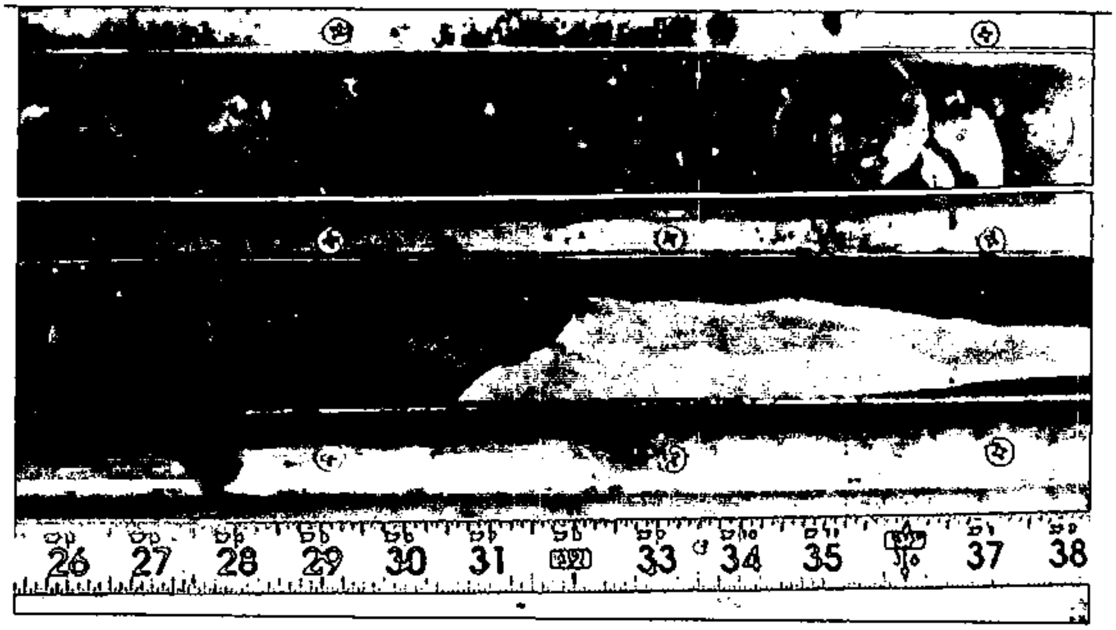
33-B88b



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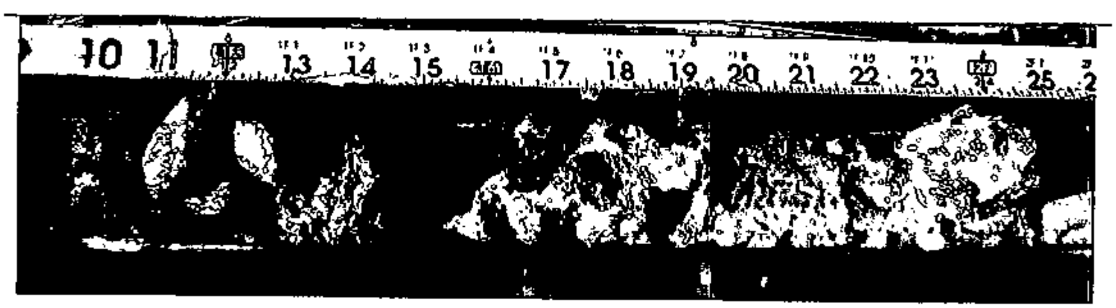

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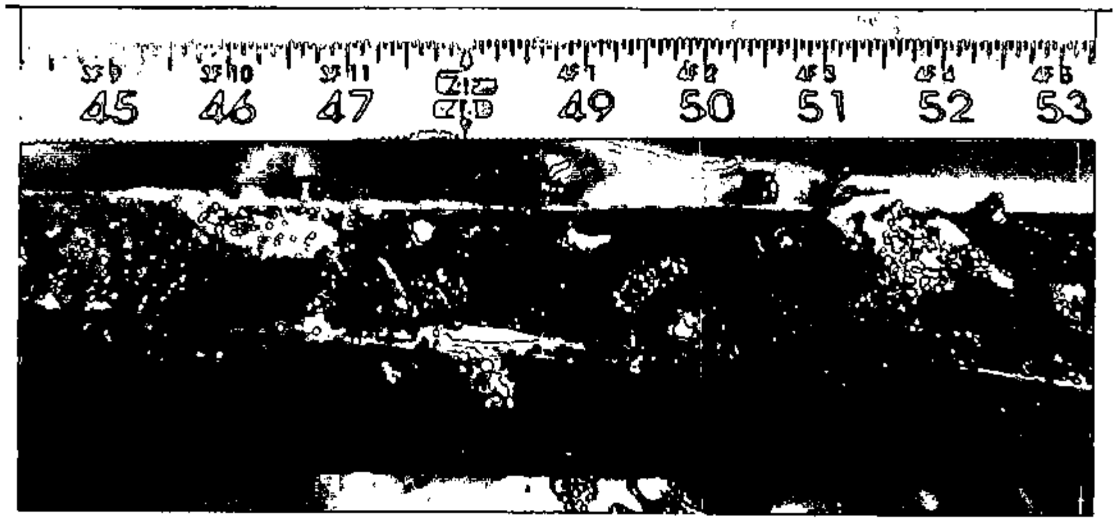

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33-B94

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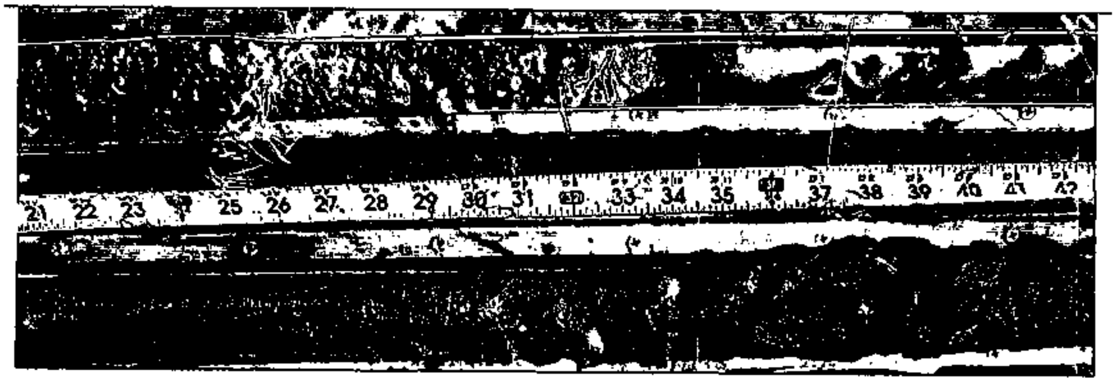
33-B95c



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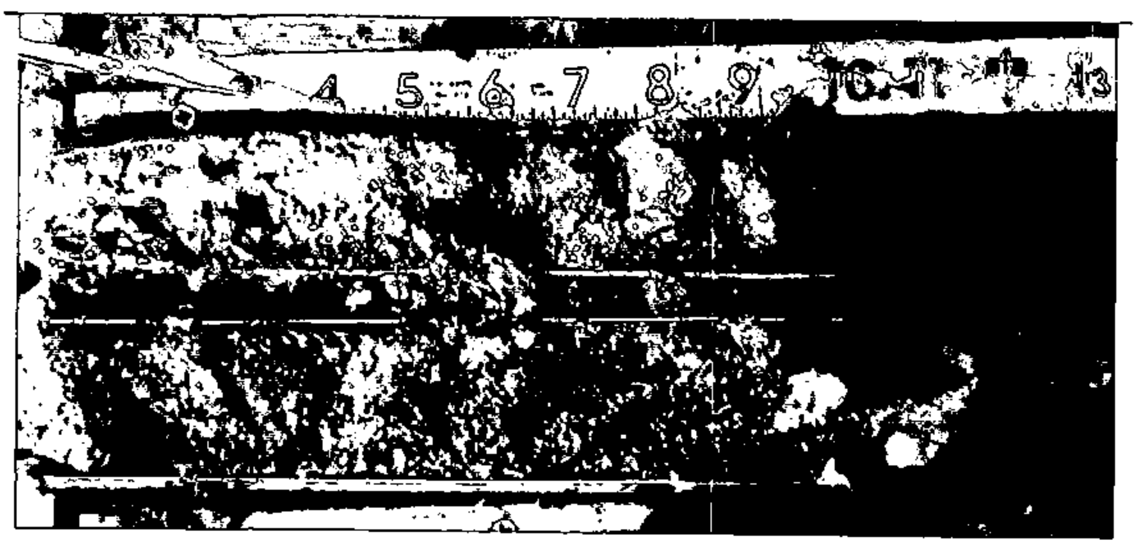
33-B96b



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33-B98

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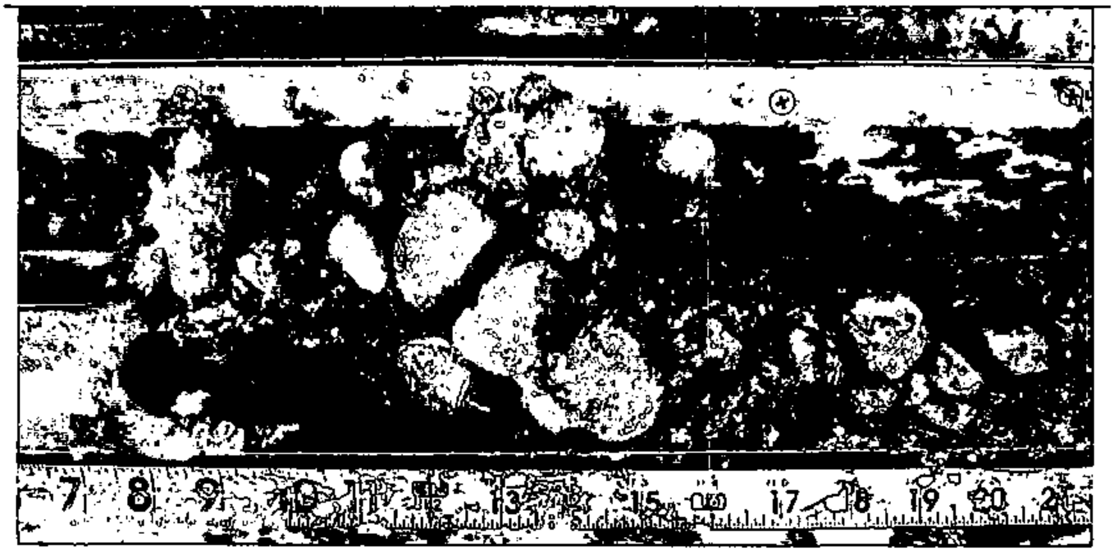

33-B101a

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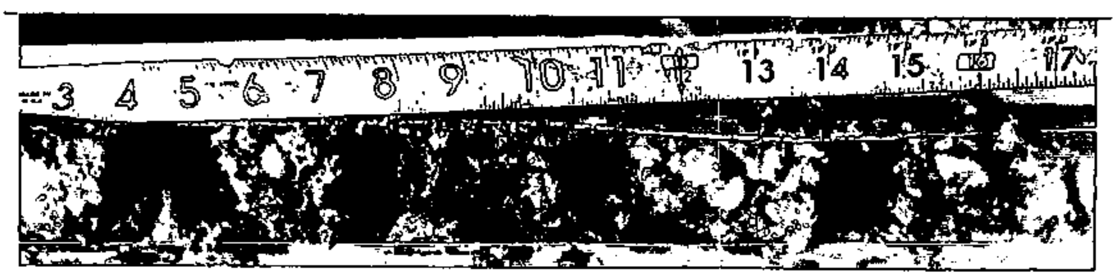
33-B105c

11

33-B106c



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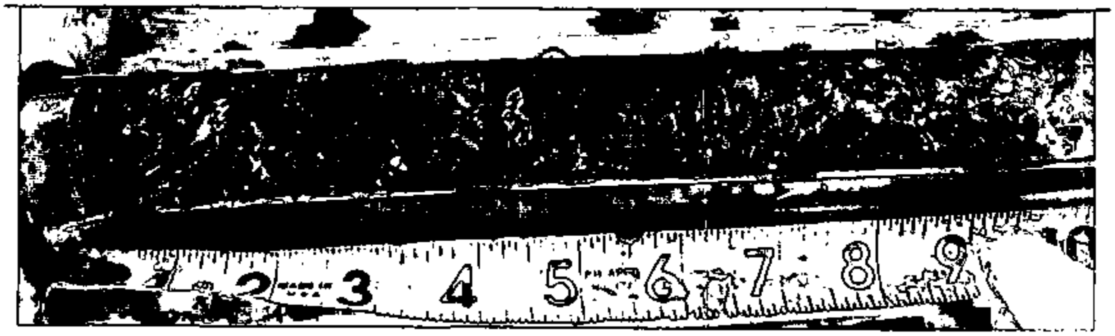
33-B107

13



33-B109

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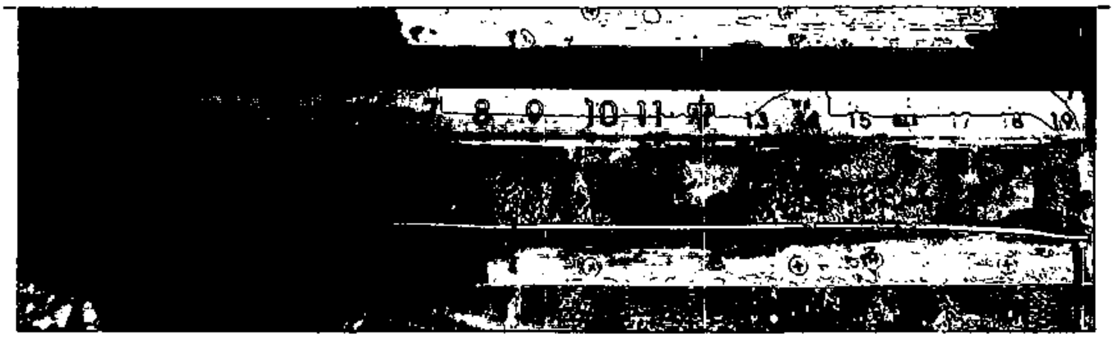
33-B112b



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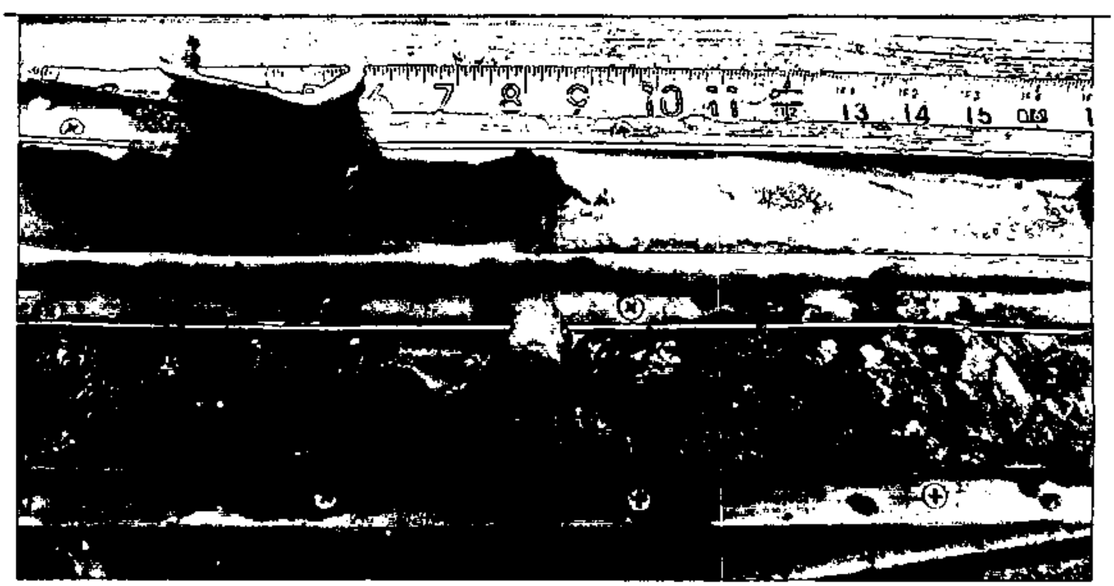
33-B113c



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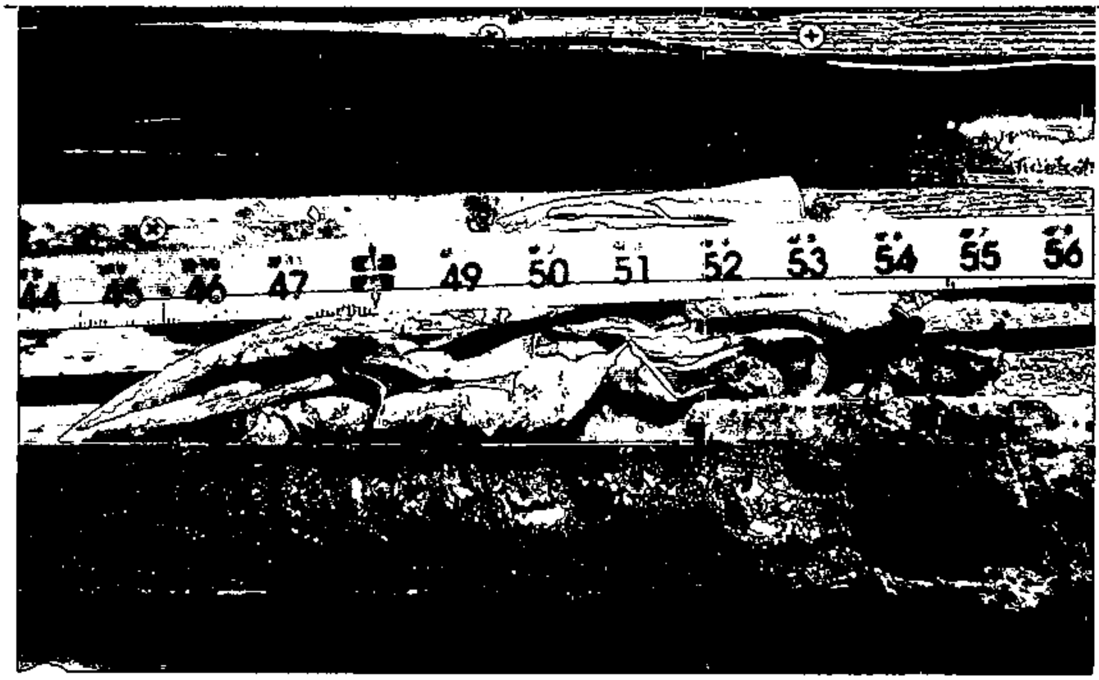
33-B115

17



33-B116b

APPENDIX E
FINAL NA ANALYSIS

UPRR Ogden Rail Yard
Table 2
Summary Table of All Data Evaluated in Natural Attenuation Protocol
9/23/2004

Parameter	Units	38-MW12	22a-MW6	22a-MW6D	38-MW2	Notes
Oxygen (meter)	mg/L	0.2-0.3	0.2-0.3	0.2-0.7	--	Based on two sampling events
Nitrate	mg/L	0.15U	0.15U	0.15U	--	Based on two sampling events
Iron II	mg/L	8.8	6.95-7.2	3.4-3.5	--	Based on two sampling events
Sulfate	mg/L	79.4-105	49.6-56.3	17.1-18.7	--	Based on two sampling events
Corrected Eh	mV	-85	-61	-108	--	Based on one sampling event
pH	--	6.8-7	6.5-7.8	6.5-7.4	--	
TOC	mg/L	18.2	16-20.4	15-25	--	Based on two sampling events
Ethane	mg/L	0.03-0.85	0.026J	<0.023-0.026J	--	Data from 22a-MW6 are based on one sampling event. Data for other wells are based on two sampling events.
Ethene		0.063-0.095	0.069J	0.069J-0.17	--	
Methane	mg/L	0.88-1.3	2.6J	4.3-5.0	--	
Temperature	°C	11-22.6	10-18.8	10-18.4	--	
Alkalinity	mg/L	477-520	579-585	567-599	386-467	Based on two sampling events
Chloride	mg/L	79.2-108	128-164	282-411	71.8-79.2	Based on two sampling events
Benzene	ug/L	2-3	4-8	2-3	--	
Toluene	ug/L	3-7	1-3	1U-1	--	
Ethylbenzene	ug/L	6-8	2-5	0.5J-2	--	
Xylenes (Total)	ug/L	18-20	3J-7	1-2	--	
BTEX (Total)	ug/L	29-38	10-23	4.5-8	--	
PCE	ug/L	5-7	0.7-1U	1U	--	
TCE	ug/L	91-430	2-4	0.9-1U		
cis 1,2-DCE	ug/L	3500	2000-3700	540-870	--	
trans 1,2-DCE	ug/L	14J	10J-37	2-13	--	
1,2-DCE (total)	ug/L	3000-5300	800-3700	42-870	--	
VC	ug/L	550-710	870-1300	130-1900	--	
1,1,1-TCA	ug/L	2200-4100	180-580	3-76	--	
1,1-DCA	ug/L	870-1200	28-66	170-810	--	
Chloroethane	ug/L	160-190	43-160	49-120	--	

Notes:
Unless stated otherwise, ranges for 22a-MW6/6D are based on four sampling events and ranges for 38-MW12 are based on three sampling events.
Cis-1,2-DCE and trans-1,2-DCE ranges are based on two sampling events, except for 38-MW12.
Only alkalinity and chloride data for 38-MW2 are presented here because only these parameters were compared to data from other wells. Other parameters from this well were not used in the screening protocol and therefore are not shown.

UPRR Ogden Rail Yard
Table 3
Natural Attenuation Screening Protocol
Revised Score
9/23/2004

Natural Attenuation Screening Protocol	Interpretation	Score	
The following is taken from the USEPA protocol (USEPA, 1998). The results of this scoring process have no regulatory significance.	Inadequate evidence for anaerobic biodegradation* of chlorinated organics	0 to 5	Score: 27
	Limited evidence for anaerobic biodegradation* of chlorinated organics	6 to 14	
	Adequate evidence for anaerobic biodegradation* of chlorinated organics	15 to 20	
	Strong evidence for anaerobic biodegradation* of chlorinated organics	>20	*Scroll to End of Table*

* reductive dechlorination

Analysis	Concentration in Most Contam. Zone	Interpretation	Yes	No	Points Awarded
Oxygen*	<0.5 mg/L	Tolerated, suppresses the reductive pathway at higher concentrations	●	○	3
	>5mg/L	Not tolerated; however, VC may be oxidized aerobically	○	●	0
Nitrate*	<1 mg/L	At higher concentrations may compete with reductive pathway	●	○	2
Iron II*	>1 mg/L	Reductive pathway possible; VC may be oxidized under Fe(III)-reducing conditions	●	○	3
Sulfate*	<20 mg/L	At higher concentrations may compete with reductive pathway	○	●	0
Sulfide*	>1 mg/L	Reductive pathway possible	○	○	0
Methane*	<0.5 mg/L	VC oxidizes	○	●	0
	>0.5 mg/L	Ultimate reductive daughter product, VC Accumulates	●	○	3
Oxidation Reduction Potential* (ORP)	<50 millivolts (mV)	Reductive pathway possible	●	○	1
	<-100mV	Reductive pathway likely	○	●	0
pH*	5 < pH < 9	Optimal range for reductive pathway	●	○	0
	5 > pH >9	Outside optimal range for reductive pathway	○	●	0
TOC	>20 mg/L	Carbon and energy source; drives dechlorination; can be natural or anthropogenic	○	●	0
Temperature*	>20°C	At T >20°C biochemical process is accelerated	○	●	0
Carbon Dioxide	>2x background	Ultimate oxidative daughter product	○	○	0
Alkalinity	>2x background	Results from interaction of carbon dioxide with aquifer minerals	○	●	0
Chloride*	>2x background	Daughter product of organic chlorine	●	○	2
Hydrogen	>1 nM	Reductive pathway possible, VC may accumulate	○	○	0
	<1 nM	VC oxidized	○	○	0
Volatile Fatty Acids	>0.1 mg/L	Intermediates resulting from biodegradation of aromatic compounds; carbon and energy source	○	○	0
BTEX*	>0.1 mg/L	Carbon and energy source; drives dechlorination	○	●	0
PCE*		Material released	●	○	0
TCE*		Material released	○	○	0
		Daughter product of PCE a/	○	○	0
DCE*		Material released	○	●	0
		Daughter product of TCE. If cis is greater than 80% of total DCE it is likely a daughter product of TCE a/; 1,1-DCE can be a chem. reaction product of TCA	●	○	2
VC*		Material released	○	●	0
		Daughter product of DCE a/	●	○	2
1,1,1-Trichloroethane*		Material released	●	○	0
DCA		Daughter product of TCA under reducing conditions	●	○	2
Carbon Tetrachloride		Material released	○	●	0
Chloroethane*		Daughter product of DCA or VC under reducing conditions	●	○	2
Ethene/Ethane	>0.01 mg/L	Daughter product of VC/ethene	●	○	2
	>0.1 mg/L	Daughter product of VC/ethene	●	○	3
Chloroform		Material released	○	●	0
		Daughter product of Carbon Tetrachloride	○	●	0
Dichloromethane		Material released	○	●	0
		Daughter product of Chloroform	○	●	0

* required analysis.
a/ Points awarded only if it can be shown that the compound is a daughter product (i.e., not a constituent of the source NAPL).

SCORE Reset

End of Form

MEMORANDUM

THE FORRESTER GROUP
INSIGHTFUL ENVIRONMENTAL SOLUTIONS™

Date: October 15, 2003

To: File

From: Jay Hoskins

Subject: UPRR Ogden Rail Yard
North and South VC Plumes
Additional Concentration vs. Time and Concentration vs. Distance Data

Two groundwater sampling events were performed under the Feasibility Study for the UPRR Ogden Rail Yard. This sampling was performed in accordance with the April 21, 2003, Additional Sampling Workplan to Assess MNA. The two most recent sampling events were performed in May and August/September 2003. The results of the sampling were analyzed for trends in vinyl chloride (VC) concentration over time. Other CVOCs (e.g., TCE, 1,1,1-TCA, and cis-1,2-DCE) that participate in the generation of VC from biotic and abiotic attenuation processes were also examined.[1]

SOUTH PLUME

Eleven South Plume wells were sampled for CVOCs in May and August/September 2003. Four of these wells are generally located along the western boundary of AOIs 26 and 30, where low levels of VC have been detected in the past.[2] In the two most recent sampling events, VC was not detected in these four wells. Concentrations of all constituents were below site screening level values (SLVs). Based on this data, the levels of CVOCs in these wells do not pose an unacceptable risk.

The other seven wells are located within the main body or along the downgradient edge of the South Plume.[3] At 30-MW4, vinyl chloride or other CVOCs were not detected in the last two sampling events. At 30-MW3, only three data points are available, and there is insufficient data to determine if a trend exits. For the remaining five wells, concentration data were examined for trends in concentration over time (Charts 1-6). Any "non-detects" were plotted as ½ the analytical detection limit. Results of the South Plume analysis are summarized in Table 1.

Order-of-magnitude type differences in concentration over time are needed to be fairly certain of any observed trend.[4] In the last three years, VC levels have significantly dropped in four South Plume wells. For the two furthest downgradient monitoring wells, plume levels are already very close to or below the

---

[1] For the C vs. T analysis, only constituents which were detected 3 or more times at a well were analyzed.

[2] 30-MW7, 26-MW1, 26-MW2, and 26-STMW1.

[3] 21-MW2, 30-MW6D, 22b-MW1, 22b-MW2D, 30-MW3, 30-MW-3, and 30-MW4.

[4] The USEPA provides guidance on interpretation of concentration vs. time and concentration vs. distance data trends in OSWER Directive 9200.4-17P, *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Sites*. The Directive states "...analysis of natural attenuation rates from many sites indicates that a measured decrease in contaminant concentrations of at least one order of magnitude is necessary to...demonstrate that the estimated rate is statistically different from zero at a 95% level of confidence."

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analytical detection limit, and therefore it is difficult to determine if concentrations at the plume edge have decreased in an order of magnitude.

Based on the above, South Plume is not expanding, and CVOC concentrations appear to be decreasing over time. In fact, it appears that the main body of the South Plume is shrinking.

NORTH PLUME

Fourteen North Plume monitoring wells were sampled in May and August/September 2003.

- Four monitoring wells are located along the western edge of the plume: 34-MW2, 34-MW8, 34-MW9, and 34-SPMW-02. 34-MW9 is the well that is closest to the Weber River.

- Two monitoring wells are located near the eastern edge of the plume: 34-MW4 and 36-MW2. VC was not detected in either of these wells.

- Seven monitoring wells are located in the main body of the plume. Listed from upgradient to downgradient, these are: 38-MW9, 38-MW12, 22a-MW6, 34-MW1, 34-MW3, 34-OB-12, and 35-MW1.

Charts 8-20 illustrate CVOC concentrations over time for the North Plume monitoring wells. Any "non-detects" were plotted as ½ the analytical detection limit. The trend analysis is summarized in Table 2.

Based on recent monitoring, the North Plume is not expanding, and CVOC concentrations appear to be steady or decreasing with time. Of particular significance is that vinyl chloride was not detected in the furthest downgradient monitoring wells in the last two sampling events. This indicates that the plume extent is smaller than suggested by previously sampling. Also, vinyl chloride has not been detected at 34-MW9 (the monitoring well closest to the river), indicating that plume impacts on the Weber River continue to be limited.

MEMORANDUM

THE FORRESTER GROUP
INSIGHTFUL ENVIRONMENTAL SOLUTIONS™

Date: October 15, 2003

To: File

From: Jay Hoskins

Subject: Natural Attenuation Screening Protocol, Revised
Ogden Rail Yard North CVOC Plume

Appendix L of the Ogden Rail Yard RI Report contains an analysis of the potential for reductive dechlorination in site groundwater and recommendations for additional data collection. The analysis concluded that based on existing data there is adequate evidence for anaerobic biodegradation of chlorinated solvents, but recommended that additional methane, ethane, and ethene (M/E/E) samples be collected to confirm that VC is also reductively dechlorinated. M/E/E samples were collected in May and June 2003 from four wells at the site[1]; laboratory results for these samples are shown in Table 1.

Either ethane or ethene was detected in the three most downgradient wells. Methane was detected in all four wells. The USEPA screening protocol score sheet was used to evaluate the significance of these detections to the evaluation of NA processes. The following conclusions were then drawn.

- For ethene/ethane, the screening protocol assesses concentrations above 0.01 mg/L as an indication that these compounds are daughter products of VC/ethene. For 38-MW12 and 22a-MW6, which are located in the area of highest CVOC concentrations, ethane/ethene concentrations are above 0.01 mg/L. This indicates that vinyl chloride in the plume is being reductively dechlorinated to ethene (and eventually to ethane).

- For methane, the screening protocol concludes that concentrations over 0.5 mg/L may be interpreted as sufficient for accumulation of vinyl chloride. Elevated levels of methane also indicate that the geochemical conditions are sufficient for reductive dechlorination of vinyl chloride to ethene.[2] At 38-MW9, 38-MW12, and 22a-MW6, methane levels were elevated above 0.5 mg/L, indicating that methanogenic conditions predominate in the region where the highest CVOC concentrations have been measured and that conditions for reduction of vinyl chloride to ethane are favorable.

Based on the above, it is reasonable to conclude that vinyl chloride is being naturally attenuated to ethene.

The natural attenuation screening protocol was then revised to reflect the M/E/E data collected in May and June 2003. Table 2 contains all data that was used to develop a site score.[3] The revised site score was 27, which indicates that there is strong evidence for anaerobic biodegradation of chlorinated organics.

---

[1] Two wells (38-MW12 and 22a-MW6D) are located in the area of the north plume where detected CVOC concentrations have been the highest. 38-MW9 and 34-MW3 are the furthest upgradient and downgradient, respectively, monitoring wells that were sampled.

[2] Wiedemeier et al. Natural Attenuation of Fuels and Chlorinated Solvents in the Subsurface. Wiley and Sons. 1997.

[3] In accordance with the score that was reported in the RI report, a decision was answered affirmatively if two wells met the screening protocol's criteria. As shown, only data from 38-MW12 and 22a-MW6D were considered in revising the site score.

UPRR Ogden Rail Yard
Table 1
Analytical Results of Additional Methane, Ethane, and Ethene Analysis
9/23/2004

Parameter	Units	Well Location and Sampling Date							
		22A-MW6	22A-MW6D		34-MW3		38-MW9	38-MW12	
		8/6/2003	5/21/2003	8/6/2003	5/21/2003	8/6/2003	5/23/2003	6/25/2003	8/6/2003
Ethane	ug/L	26 J	< 23	15	3.6	13	< 5.6	30	8.5
Ethene	ug/L	69 J	170	180	< 0.7	1	< 1.3	95	63
Methane	ug/L	2600 J	4300	5000	87	630	720	1300	880

Table 1
UPRR Ogden Rail Yard
Summary Table of Data Analysis for South Plume Monitoring Wells

Monitoring Well	Location	Concentration vs. Time Trend	Discussion
30-MW7 26-MW1 26-MW2 26-STMW1	Extreme western edge of South Plume	NA	Historically, low levels of VC have been detected at these wells. Vinyl chloride was not detected in these wells in the last two sampling events.
21-MW2	Furthest upgradient South Plume well	Decreasing	VC and TCE concentrations appear to be decreasing over time. Cis-1,2-DCE concentrations were steady over time.
30-MW6D	Center of South Plume	Decreasing	VC, cis-1,2-DCE, and 1,1-DCE concentrations all appear to be decreasing over time
22b-MW1	Eastern edge of South Plume	Decreasing	VC and cis-1,2-DCE concentrations appear to be decreasing over time.
22b-MW2D	Center, downgradient end of South Plume	Decreasing	VC and cis-1,2-DCE concentrations appear to be decreasing over time.
30-MW4	Downgradient edge of South Plume	NA	Low levels of VC have been detected at this well in the past. Vinyl chloride was not detected in the last two sampling events.
30-MW3	Cross-gradient edge of South Plume	NA	Low levels of VC have been detected at this well in the past. Vinyl chloride was not detected in the last two sampling events.
30-MW-3	Downgradient edge of South Plume	Steady or Decreasing	It is difficult to distinguish between a steady or shrinking plume given 1) when VC has been detected it has been at very low levels and 2) VC has not been detected in three of the last four sampling events.

NA : Not analyzed. Wells where VC nor other CVOCs were detected in the last two sampling events were not analyzed because levels have decreased below SLVs

Table 2
UPRR Ogden Rail Yard
Summary Table of Data Analysis for North Plume Monitoring Wells

Monitoring Well	Location	Concentration vs. Time Trend	Discussion
34-MW2	Western edge of North Plume	Steady	VC concentrations detected in 2003 are higher than than levels detected in 1998, but are roughly equivalent to levels detected in 2000 01. cis-1,2-DCE and 1,1-DCA concentrations are steady over time.
34-MW8	Western edge of North Plume	Decreasing	VC and cis-1,2-DCE concentrations have decreased over an order of magnitude since 2000. 1,1-DCA concentrations have remained steady.
34-MW9	Western edge of North Plume, closest well to Weber River	Steady	VC has not been detected at 34-MW9. Low levels of 1,1-DCA have been detected in some samples, but a definite trend is not evident.
34-SPMW-02	Western edge of North Plume	Steady	VC, 1,1-DCA, and chloroethane concentrations are steady over time.
34-MW4	Eastern edge of North Plume	Steady or Decreasing	VC, cis-1,2-DCE, and 1,1-DCA concentrations have decreased. 1,1,1-TCA, PCE, and TCE concentrations appear to be steady.
36-MW2	Beyond eastern edge of North Plume	Steady or Decreasing	VC and cis-1,2-DCE concentrations have decreased, but levels are of the same order of magnitude over time.
38-MW9	Furthest upgradient North Plume well	Decreasing	VC, cis-1,2-DCE, 1,1-DCA, and chloroethane concentrations are decreasing over time.
38-MW12	Center of North Plume and apparent source area downgradient of 38-MW9	Steady	Concentrations of all CVOCs were steady through time.
22a-MW6	Center of North Plume, downgradient of 38-MW12	Steady or Decreasing	VC and 1,1-DCA concentrations are steady over time. 1,1,1-TCA, 1,1-DCE, and cis-1,2-DCE indicate an increasing trend.
34-MW1	Center of North Plume, downgradient of 22a-MW6	Decreasing	VC, cis-1,2-DCE, 1,1-DCA, and TCE concentrations decreased over time.
34-MW3	Center of North Plume, downgradient of 34-MW1	Steady or Decreasing	1,1-DCA and VC levels detected in 2003 are higher than 1998 levels, but roughly equivalent to 2000-01 levels. Cis-1,2-DCE levels appear to have decreased since 2000-01.
34-OB-12	Center of North Plume, downgradient of 34-MW3	Decreasing	VC and 1,1-DCA have decreased over time. VC was not detected in the last two sampling events.
35-MW1	Furthest downgradient North Plume well	Steady or Decreasing	It is difficult to distinguish between a steady or shrinking plume given 1) when VC has been detected it has been at very low levels and 2) VC has not been detected in the last two sampling events.

ATTACHMENT
CONCENTRATION VS. TIME CHARTS

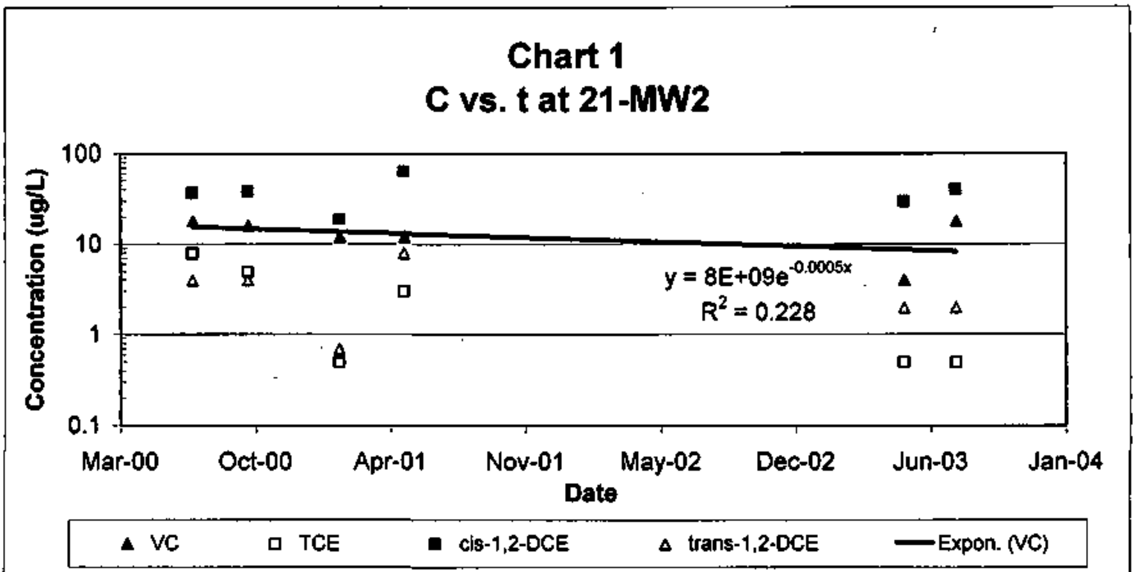
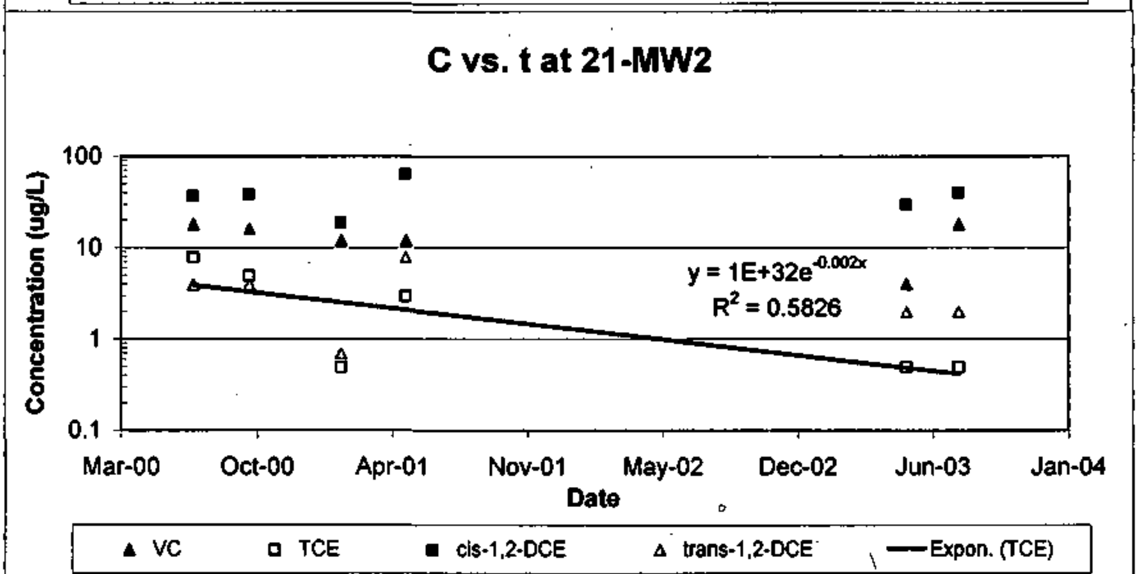
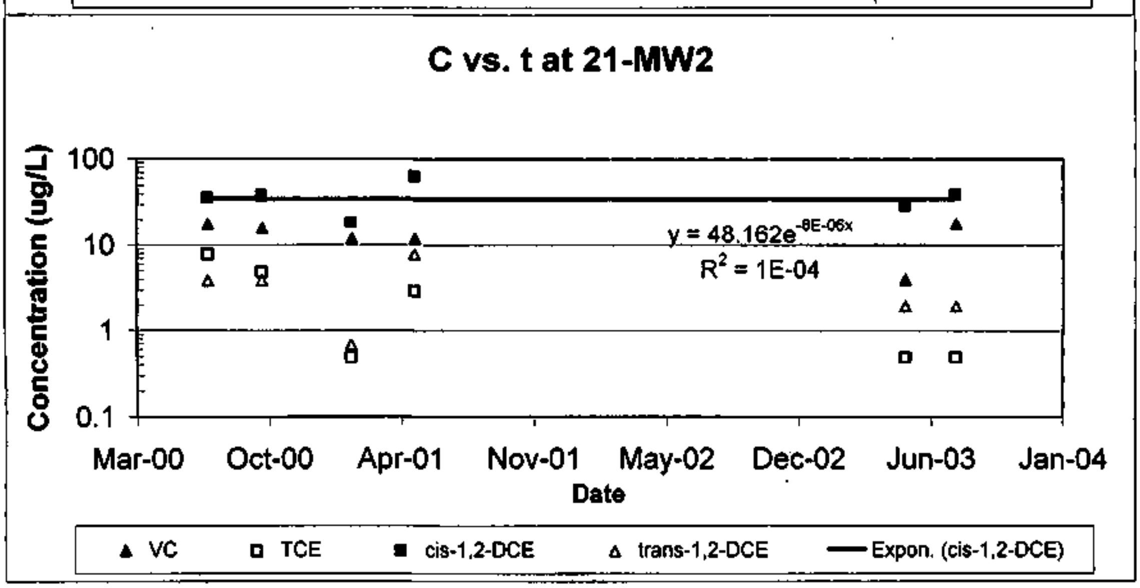


Chart 1
C vs. t at 21-MW2
Concentration (ug/L)
100
10
1
0.1
Mar-00
Oct-00
Apr-01
Nov-01
May-02
Dec-02
Jun-03
Jan-04
Date
y = 8E+09e^-0.0005x
R^2 = 0.228
VC
TCE
cis-1,2-DCE
trans-1,2-DCE
Expon. (VC)



C vs. t at 21-MW2
Concentration (ug/L)
100
10
1
0.1
Mar-00
Oct-00
Apr-01
Nov-01
May-02
Dec-02
Jun-03
Jan-04
Date
y = 1E+32e^-0.002x
R^2 = 0.5826
VC
TCE
cis-1,2-DCE
trans-1,2-DCE
Expon. (TCE)



C vs. t at 21-MW2
Concentration (ug/L)
100
10
1
0.1
Mar-00
Oct-00
Apr-01
Nov-01
May-02
Dec-02
Jun-03
Jan-04
Date
y = 48.162e^-8E-06x
R^2 = 1E-04
VC
TCE
cis-1,2-DCE
trans-1,2-DCE
Expon. (cis-1,2-DCE)

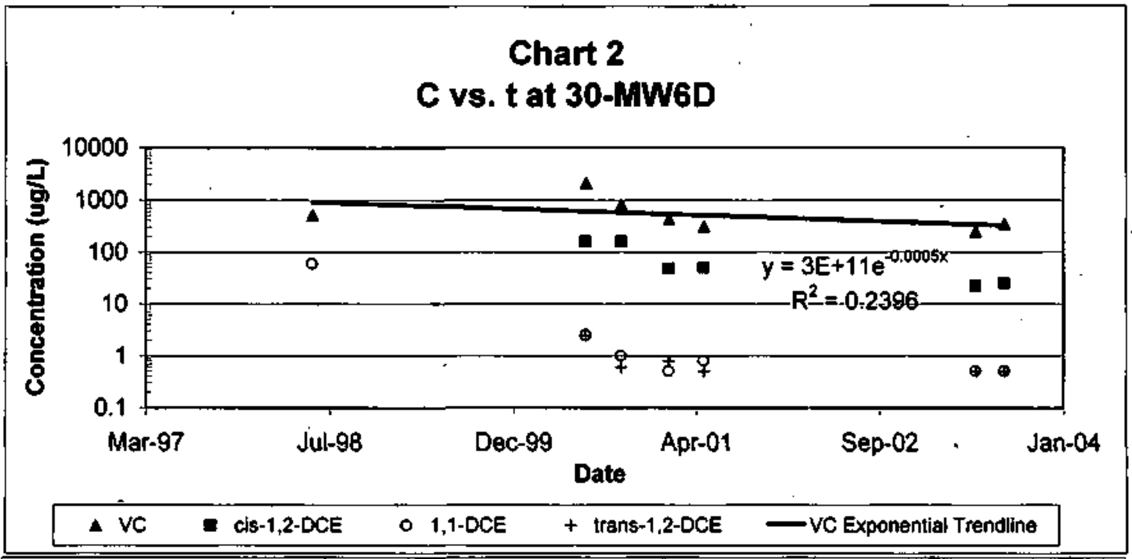
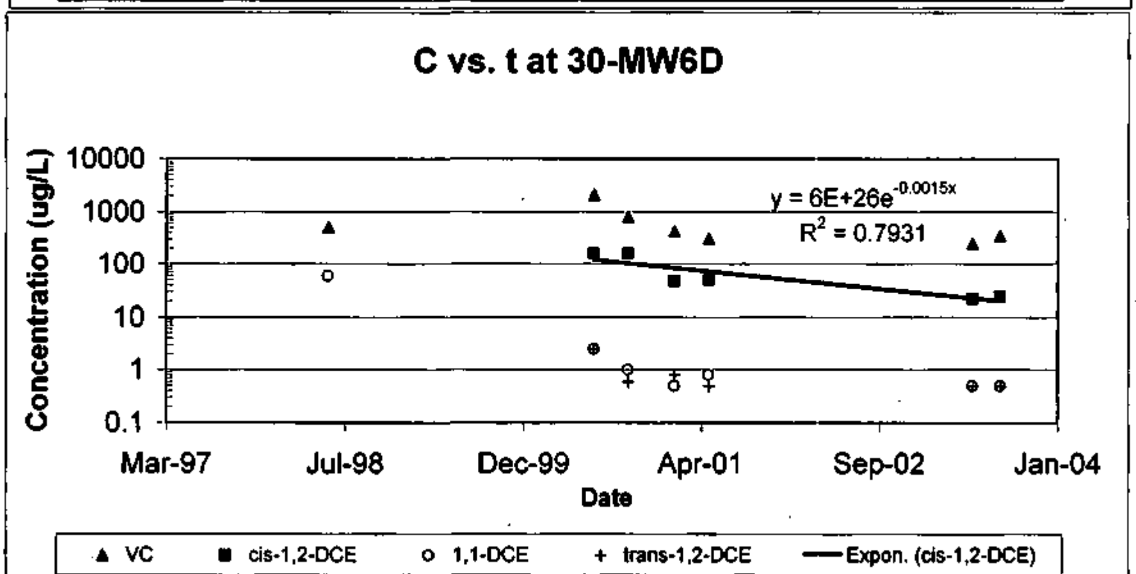
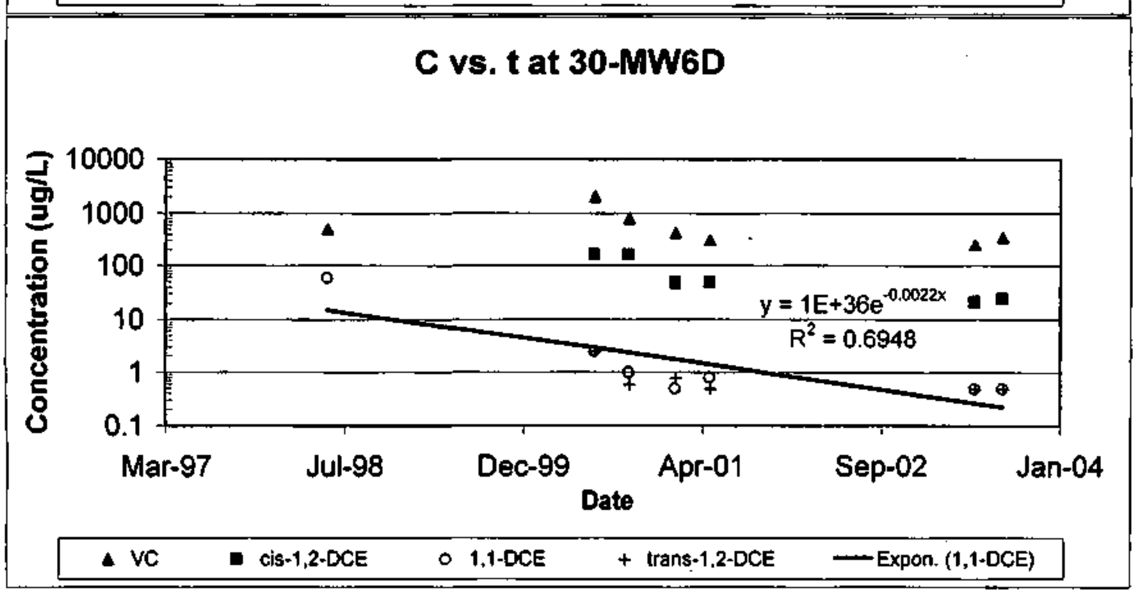


Chart 2
C vs. t at 30-MW6D
Concentration (ug/L)
10000
1000
100
10
1
0.1
y = 3E+11e^-0.0005x
R² = 0.2396
Mar-97
Jul-98
Dec-99
Apr-01
Sep-02
Jan-04
Date
VC
cis-1,2-DCE
1,1-DCE
trans-1,2-DCE
VC Exponential Trendline


C vs. t at 30-MW6D
Concentration (ug/L)
10000
1000
100
10
1
0.1
y = 6E+26e^-0.0015x
R² = 0.7931
Mar-97
Jul-98
Dec-99
Apr-01
Sep-02
Jan-04
Date
VC
cis-1,2-DCE
1,1-DCE
trans-1,2-DCE
Expon. (cis-1,2-DCE)


C vs. t at 30-MW6D
Concentration (ug/L)
10000
1000
100
10
1
0.1
y = 1E+36e^-0.0022x
R² = 0.6948
Mar-97
Jul-98
Dec-99
Apr-01
Sep-02
Jan-04
Date
VC
cis-1,2-DCE
1,1-DCE
trans-1,2-DCE
Expon. (1,1-DCE)

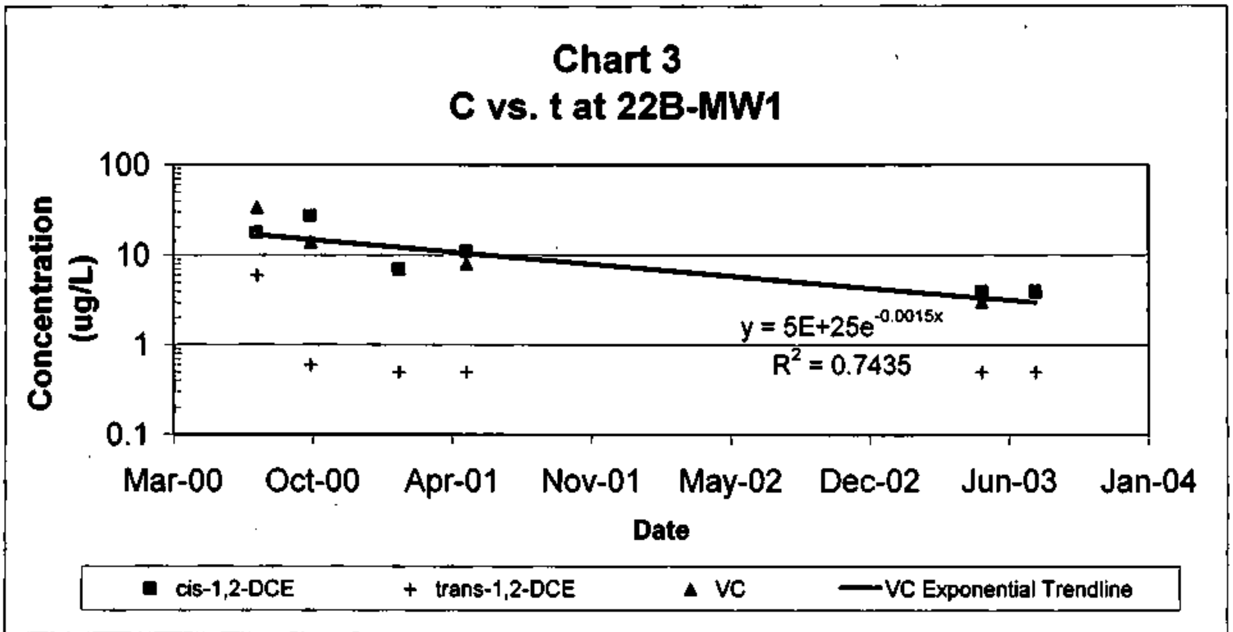
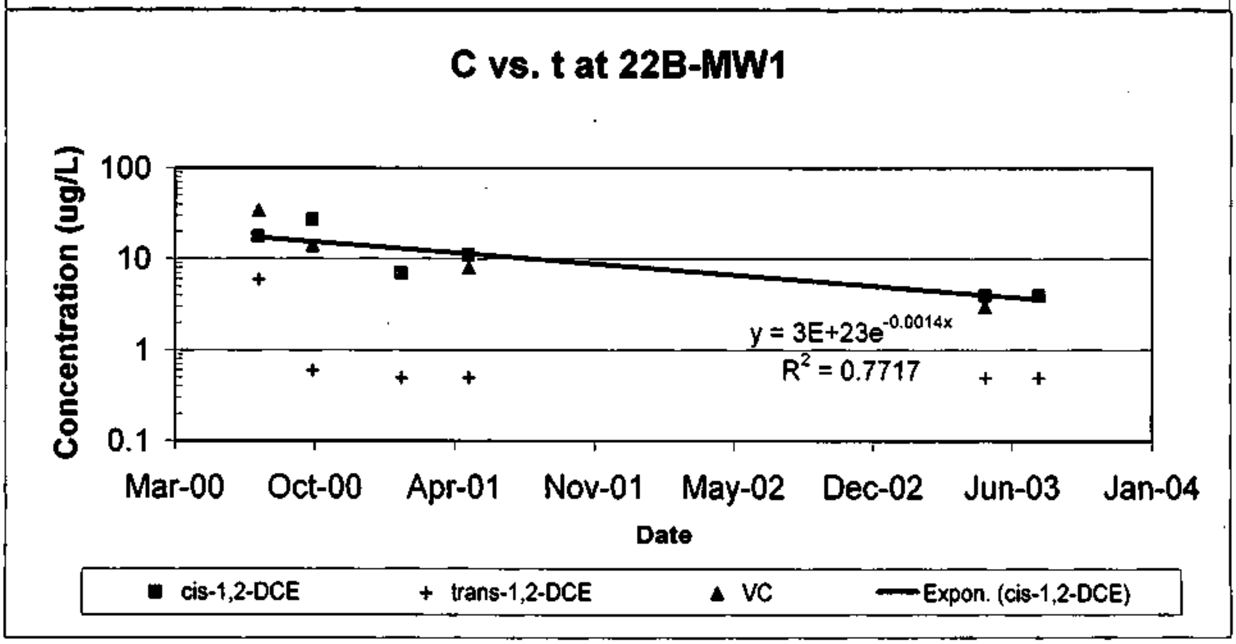


Chart 3
C vs. t at 22B-MW1
Concentration (ug/L)
100
10
1
0.1
Mar-00
Oct-00
Apr-01
Nov-01
May-02
Dec-02
Jun-03
Jan-04
Date
y = 5E+25e^-0.0015x
R^2 = 0.7435
cis-1,2-DCE
trans-1,2-DCE
VC
VC Exponential Trendline



C vs. t at 22B-MW1
Concentration (ug/L)
100
10
1
0.1
Mar-00
Oct-00
Apr-01
Nov-01
May-02
Dec-02
Jun-03
Jan-04
Date
y = 3E+23e^-0.0014x
R^2 = 0.7717
cis-1,2-DCE
trans-1,2-DCE
VC
Expon. (cis-1,2-DCE)

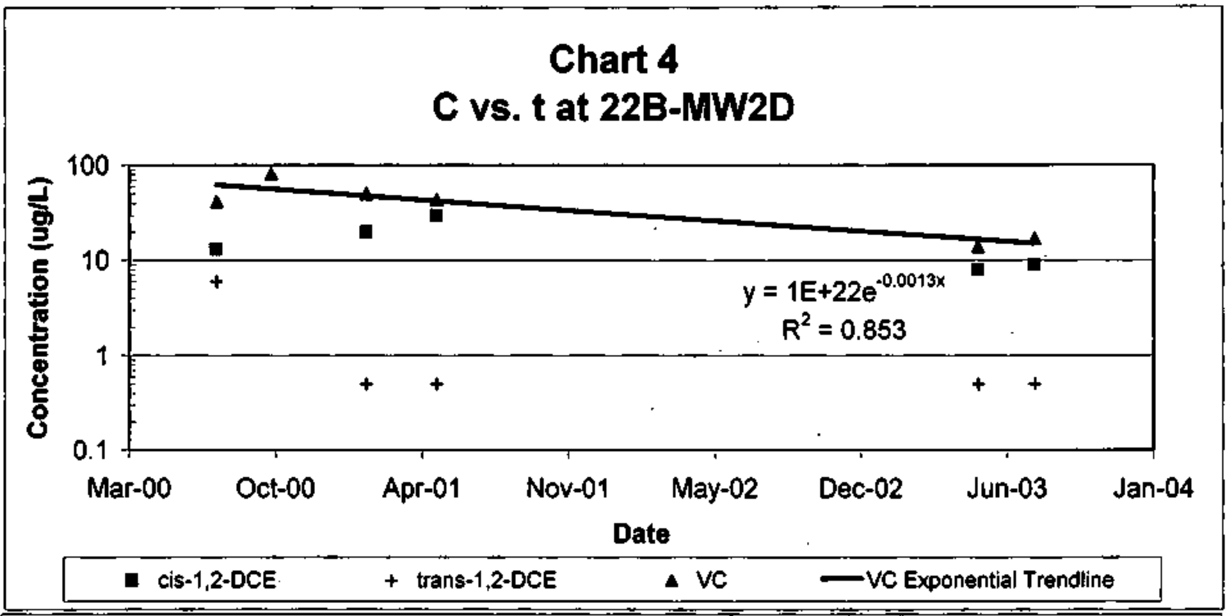
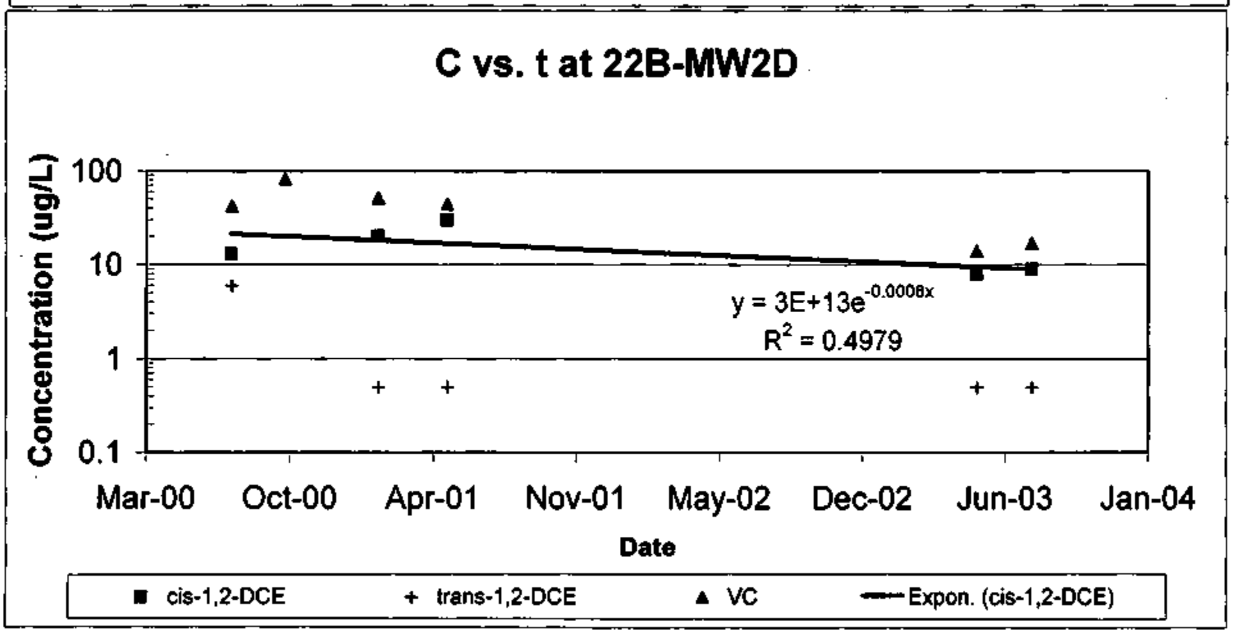


Chart 4
C vs. t at 22B-MW2D
Concentration (ug/L)
100
10
1
0.1
y = 1E+22e^-0.0013x
R^2 = 0.853
Mar-00
Oct-00
Apr-01
Nov-01
May-02
Dec-02
Jun-03
Jan-04
Date
cis-1,2-DCE
trans-1,2-DCE
VC
VC Exponential Trendline



C vs. t at 22B-MW2D
Concentration (ug/L)
100
10
1
0.1
y = 3E+13e^-0.0008x
R^2 = 0.4979
Mar-00
Oct-00
Apr-01
Nov-01
May-02
Dec-02
Jun-03
Jan-04
Date
cis-1,2-DCE
trans-1,2-DCE
VC
Expon. (cis-1,2-DCE)

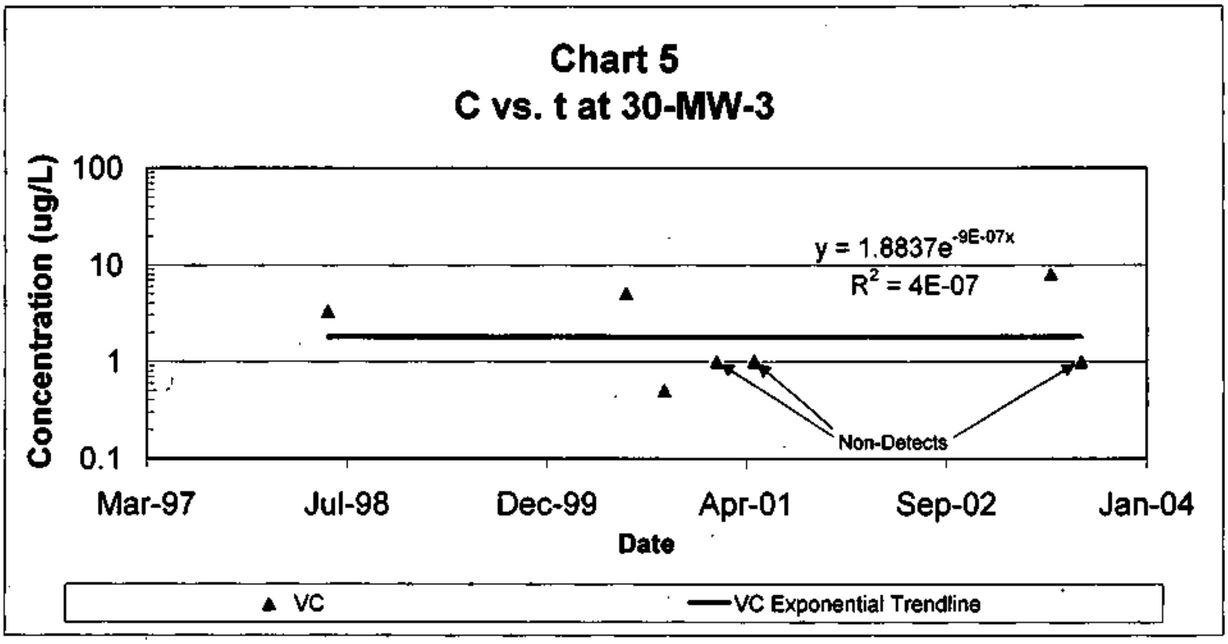


Chart 5
C vs. t at 30-MW-3
Concentration (ug/L)
100
10
1
0.1
y = 1.8837e-9E-07x
R2 = 4E-07
Non-Detects
Mar-97
Jul-98
Dec-99
Apr-01
Sep-02
Jan-04
Date
VC
VC Exponential Trendline

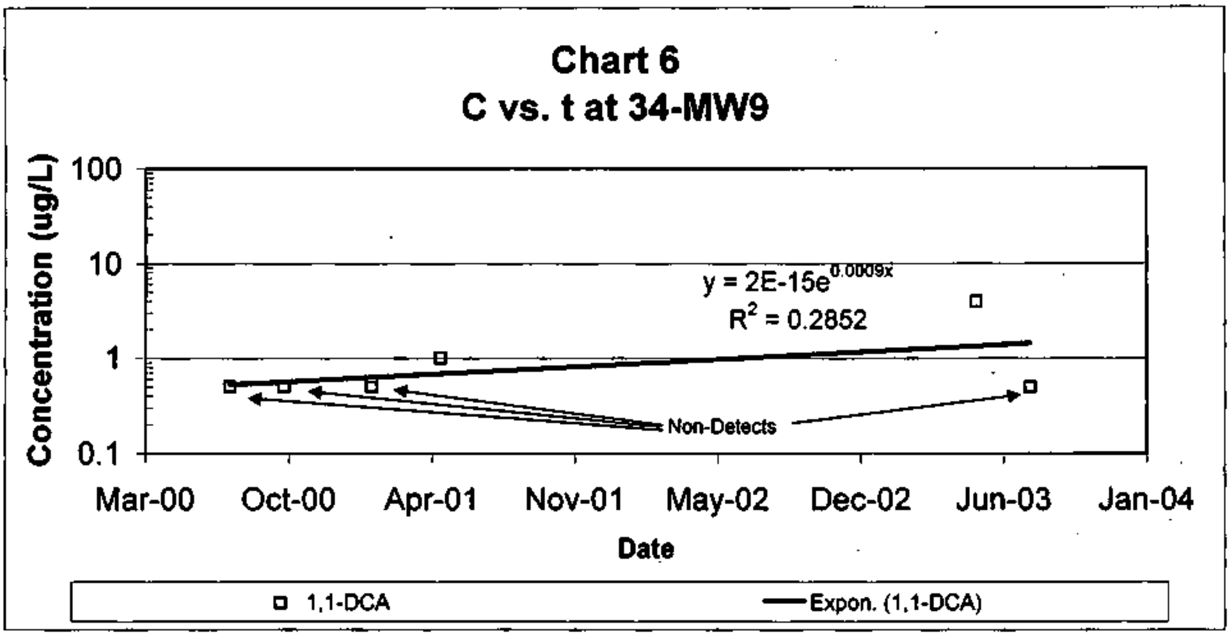


Chart 6
C vs. t at 34-MW9
Concentration (ug/L)
100
10
1
0.1
y = 2E-15e^0.0009x
R^2 = 0.2852
Non-Detects
Mar-00
Oct-00
Apr-01
Nov-01
May-02
Dec-02
Jun-03
Jan-04
Date
1,1-DCA
Expon. (1,1-DCA)

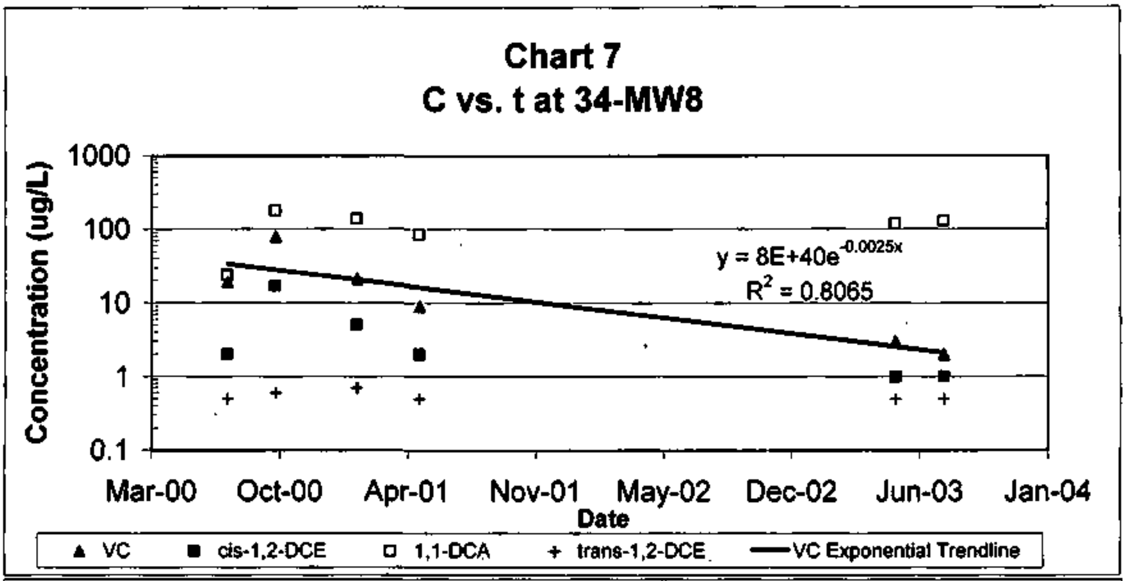
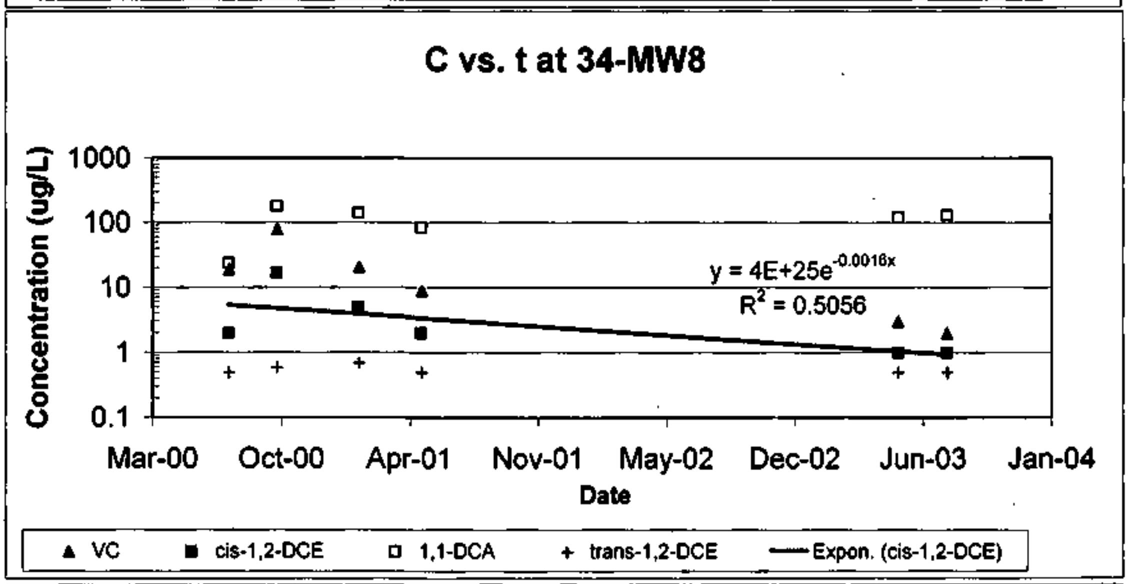


Chart 7
C vs. t at 34-MW8
Concentration (ug/L)
1000
100
10
1
0.1
Mar-00
Oct-00
Apr-01
Nov-01
May-02
Dec-02
Jun-03
Jan-04
Date
y = 8E+40e^-0.0025x
R^2 = 0.8065
VC
cis-1,2-DCE
1,1-DCA
trans-1,2-DCE
VC Exponential Trendline


C vs. t at 34-MW8
Concentration (ug/L)
1000
100
10
1
0.1
Mar-00
Oct-00
Apr-01
Nov-01
May-02
Dec-02
Jun-03
Jan-04
Date
y = 4E+25e^-0.0016x
R^2 = 0.5056
VC
cis-1,2-DCE
1,1-DCA
trans-1,2-DCE
Expon. (cis-1,2-DCE)

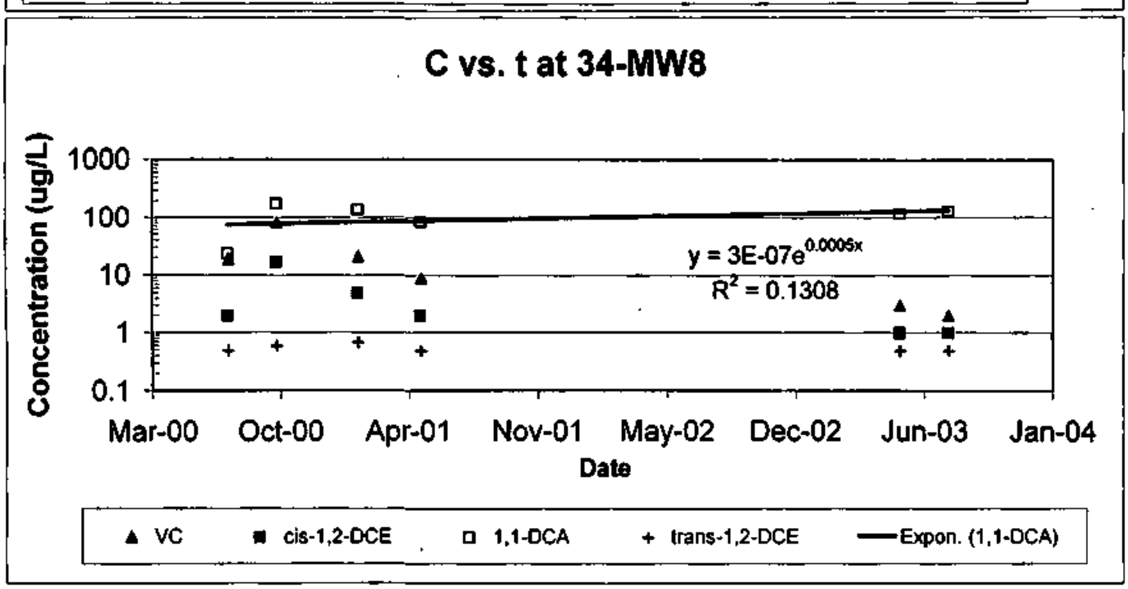
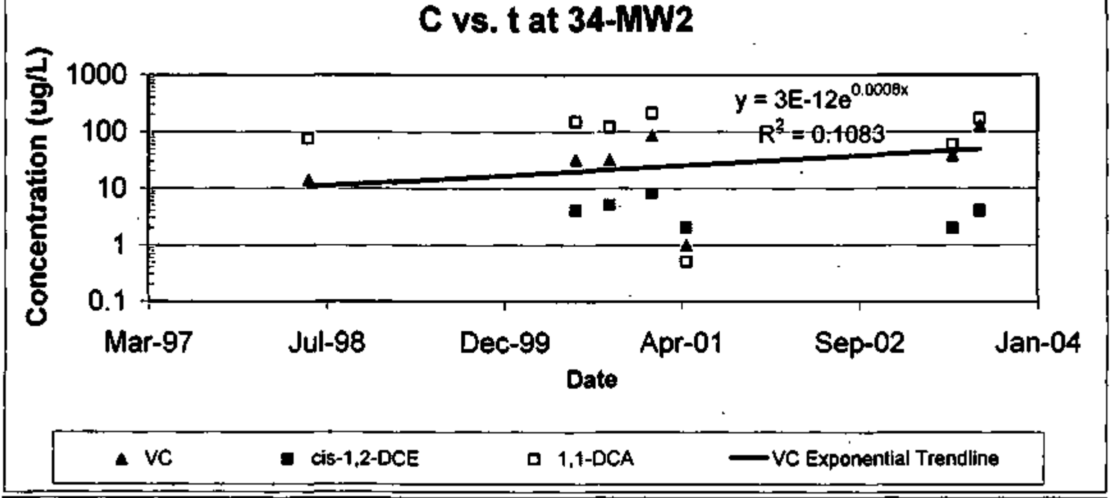
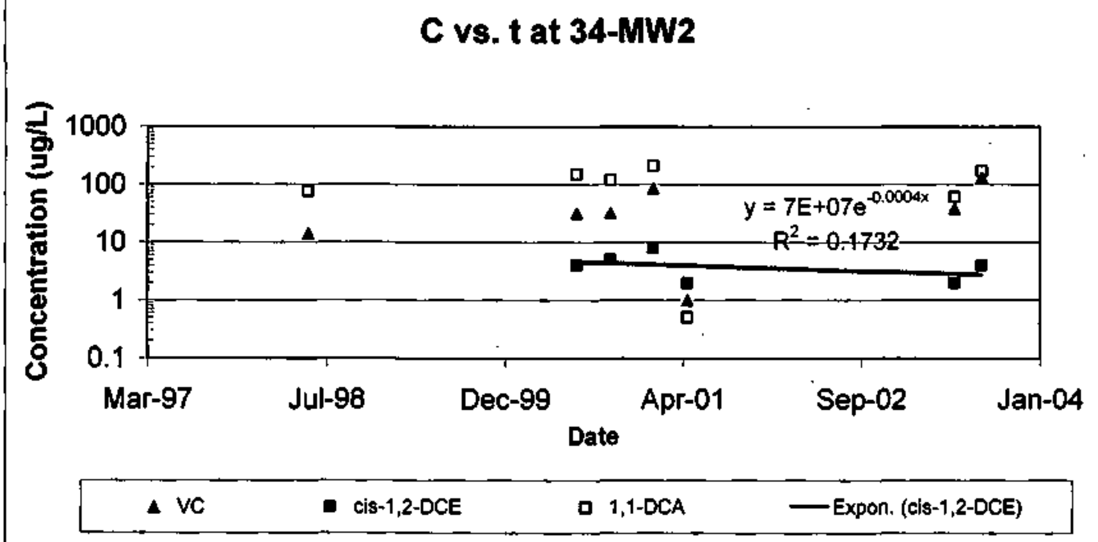

C vs. t at 34-MW8
Concentration (ug/L)
1000
100
10
1
0.1
Mar-00
Oct-00
Apr-01
Nov-01
May-02
Dec-02
Jun-03
Jan-04
Date
y = 3E-07e^0.0005x
R^2 = 0.1308
VC
cis-1,2-DCE
1,1-DCA
trans-1,2-DCE
Expon. (1,1-DCA)

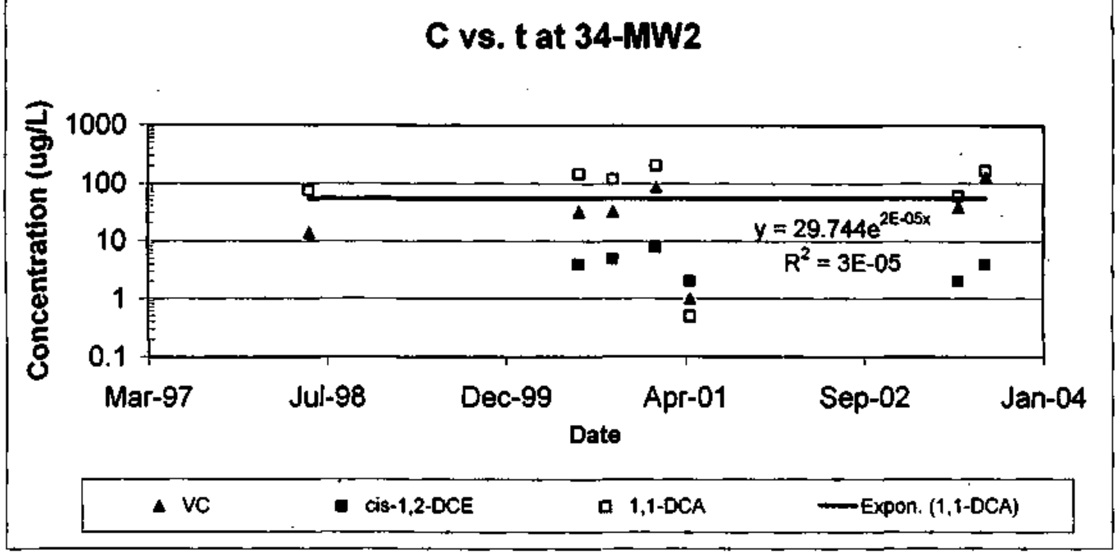
Chart 8



C vs. t at 34-MW2
Concentration (ug/L)
1000
100
10
1
0.1
y = 3E-12e^0.0008x
R² = 0.1083
Mar-97
Jul-98
Dec-99
Apr-01
Sep-02
Jan-04
Date
VC
cis-1,2-DCE
1,1-DCA
VC Exponential Trendline



C vs. t at 34-MW2
Concentration (ug/L)
1000
100
10
1
0.1
y = 7E+07e^-0.0004x
R² = 0.1732
Mar-97
Jul-98
Dec-99
Apr-01
Sep-02
Jan-04
Date
VC
cis-1,2-DCE
1,1-DCA
Expon. (cis-1,2-DCE)



C vs. t at 34-MW2
Concentration (ug/L)
1000
100
10
1
0.1
y = 29.744e^2E-05x
R² = 3E-05
Mar-97
Jul-98
Dec-99
Apr-01
Sep-02
Jan-04
Date
VC
cis-1,2-DCE
1,1-DCA
Expon. (1,1-DCA)

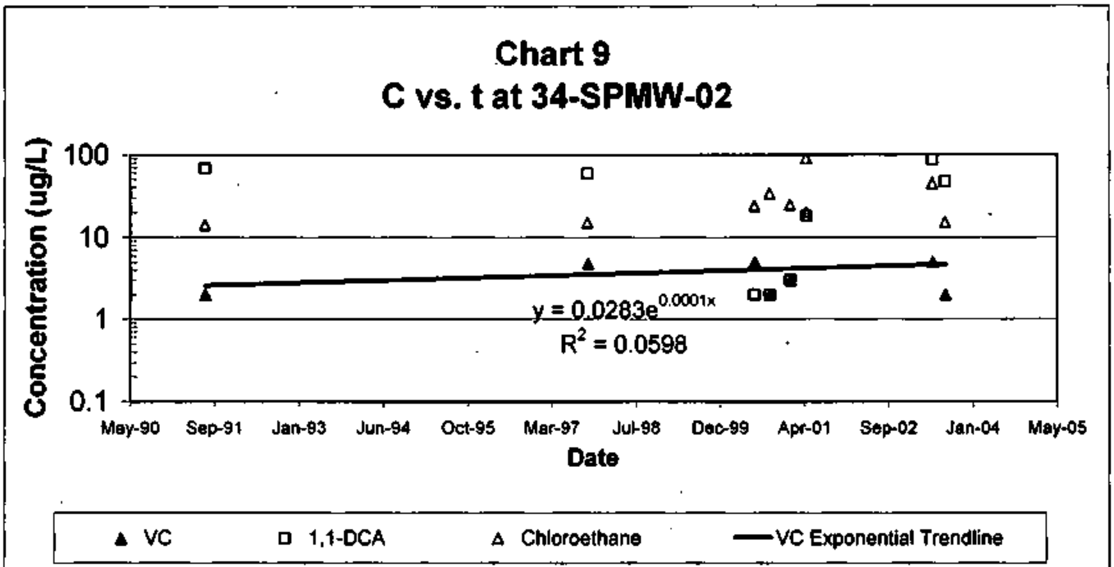
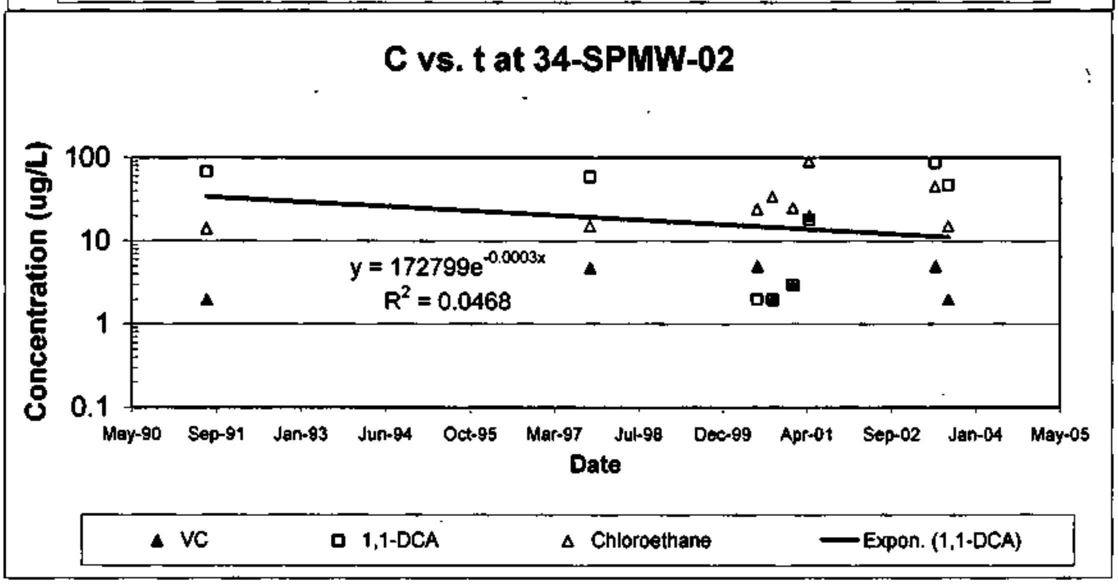
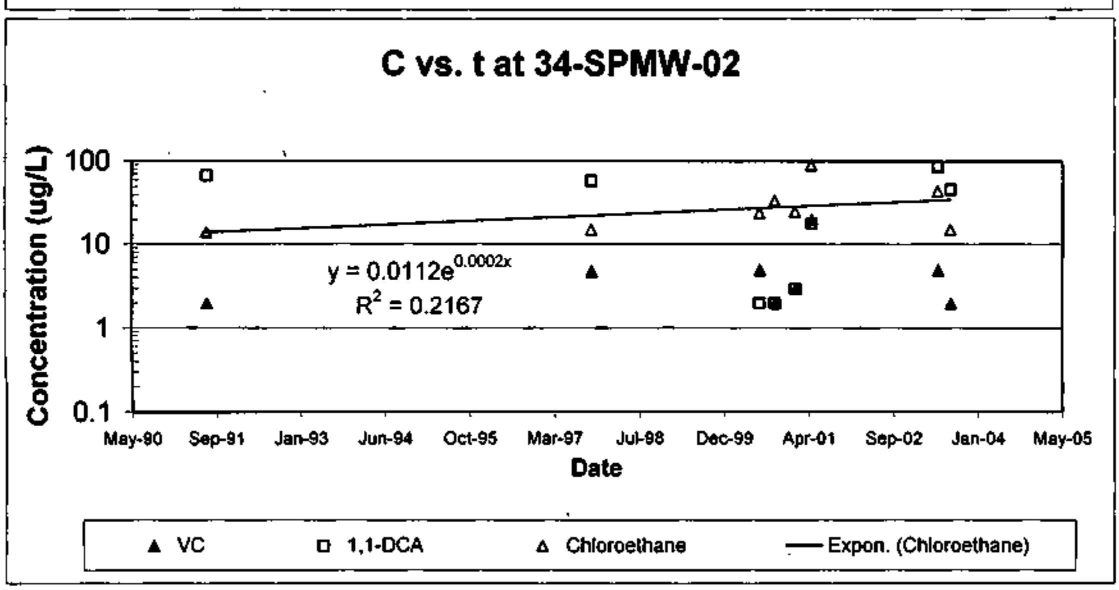


Chart 9
C vs. t at 34-SPMW-02
Concentration (ug/L)
100
10
1
0.1
May-90 Sep-91 Jan-93 Jun-94 Oct-95 Mar-97 Jul-98 Dec-99 Apr-01 Sep-02 Jan-04 May-05
Date
y = 0.0283e^0.0001x
R^2 = 0.0598
VC
1,1-DCA
Chloroethane
VC Exponential Trendline


C vs. t at 34-SPMW-02
Concentration (ug/L)
100
10
1
0.1
May-90 Sep-91 Jan-93 Jun-94 Oct-95 Mar-97 Jul-98 Dec-99 Apr-01 Sep-02 Jan-04 May-05
Date
y = 172799e^-0.0003x
R^2 = 0.0468
VC
1,1-DCA
Chloroethane
Expon. (1,1-DCA)


C vs. t at 34-SPMW-02
Concentration (ug/L)
100
10
1
0.1
May-90 Sep-91 Jan-93 Jun-94 Oct-95 Mar-97 Jul-98 Dec-99 Apr-01 Sep-02 Jan-04 May-05
Date
y = 0.0112e^0.0002x
R^2 = 0.2167
VC
1,1-DCA
Chloroethane
Expon. (Chloroethane)

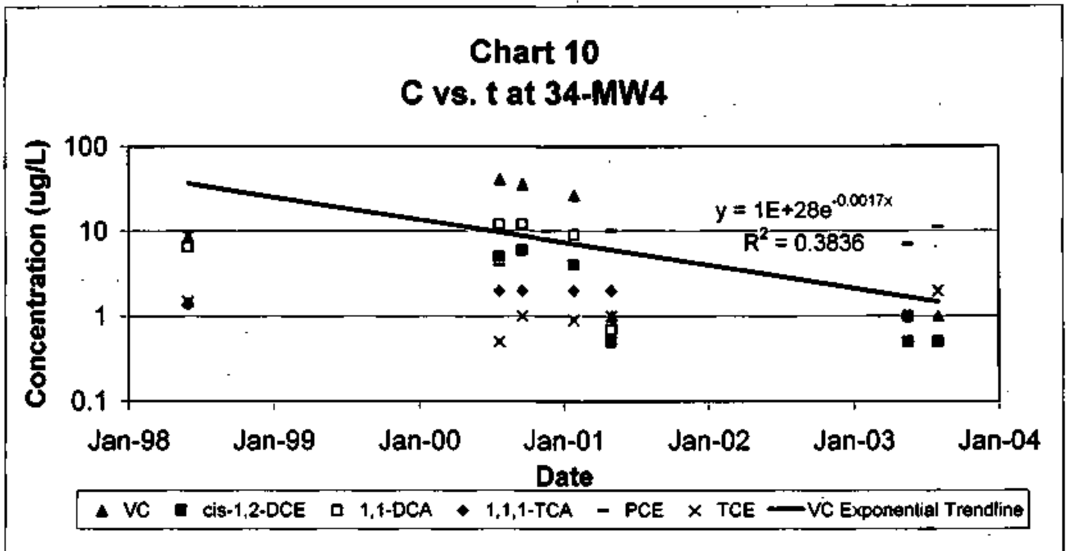
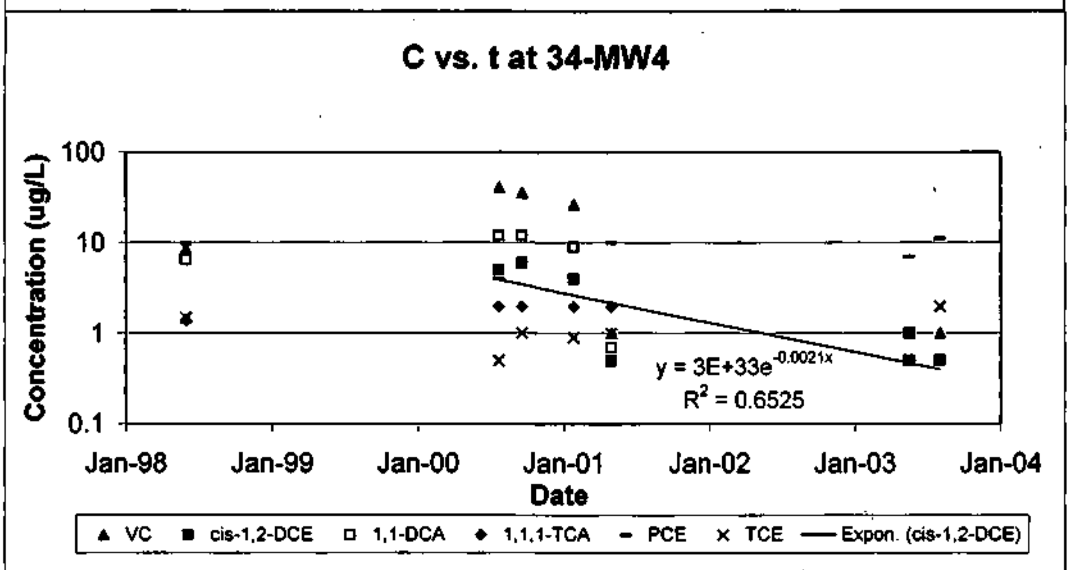
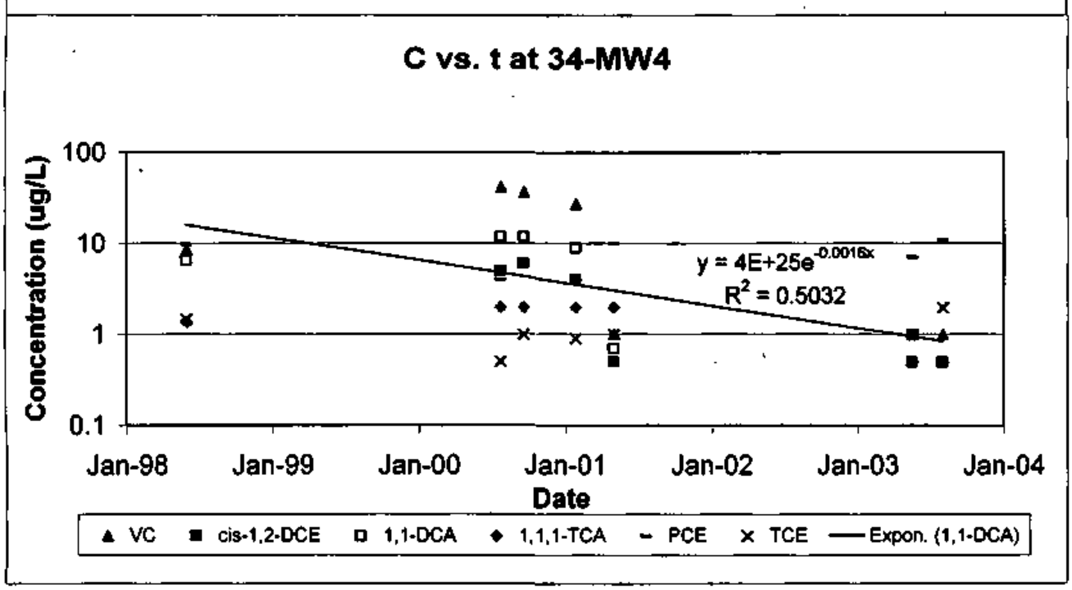


Chart 10
C vs. t at 34-MW4
Concentration (ug/L)
100
10
1
0.1
y = 1E+28e^-0.0017x
R^2 = 0.3836
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Date
VC
cis-1,2-DCE
1,1-DCA
1,1,1-TCA
PCE
TCE
VC Exponential Trendline



C vs. t at 34-MW4
Concentration (ug/L)
100
10
1
0.1
y = 3E+33e^-0.0021x
R^2 = 0.6525
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Date
VC
cis-1,2-DCE
1,1-DCA
1,1,1-TCA
PCE
TCE
Expon. (cis-1,2-DCE)



C vs. t at 34-MW4
Concentration (ug/L)
100
10
1
0.1
y = 4E+25e^-0.0016x
R^2 = 0.5032
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Date
VC
cis-1,2-DCE
1,1-DCA
1,1,1-TCA
PCE
TCE
Expon. (1,1-DCA)

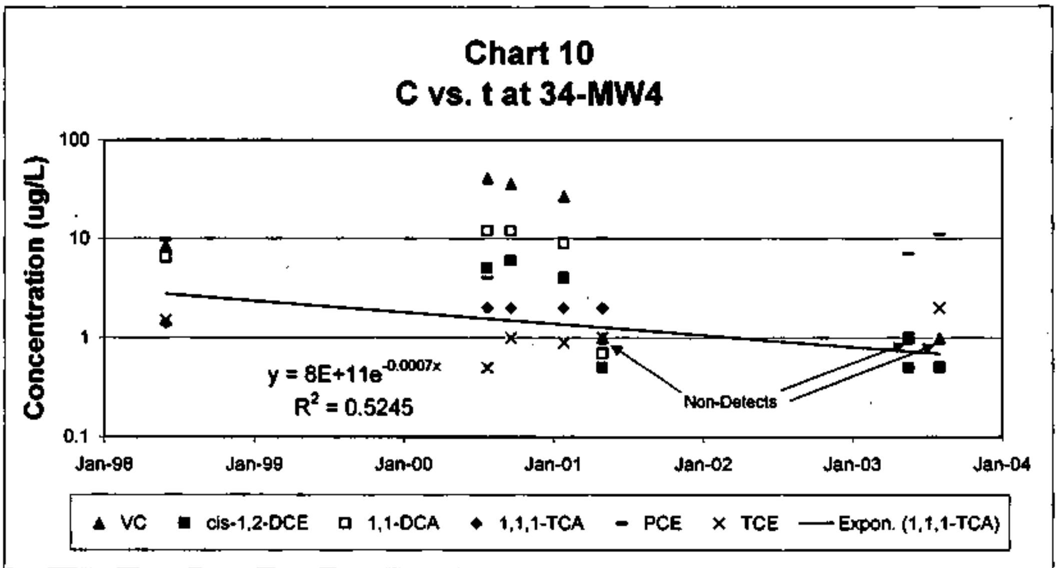
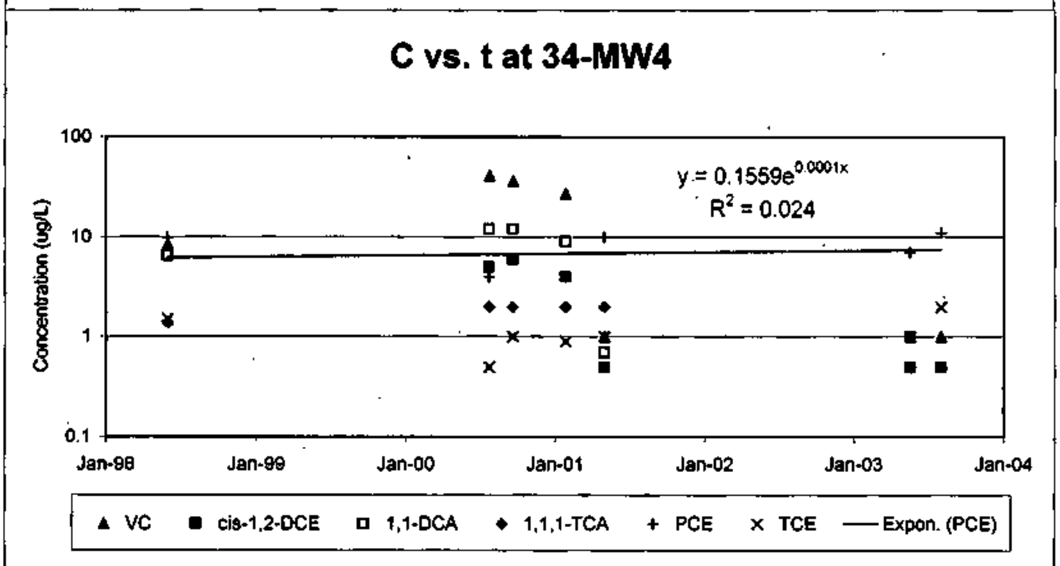
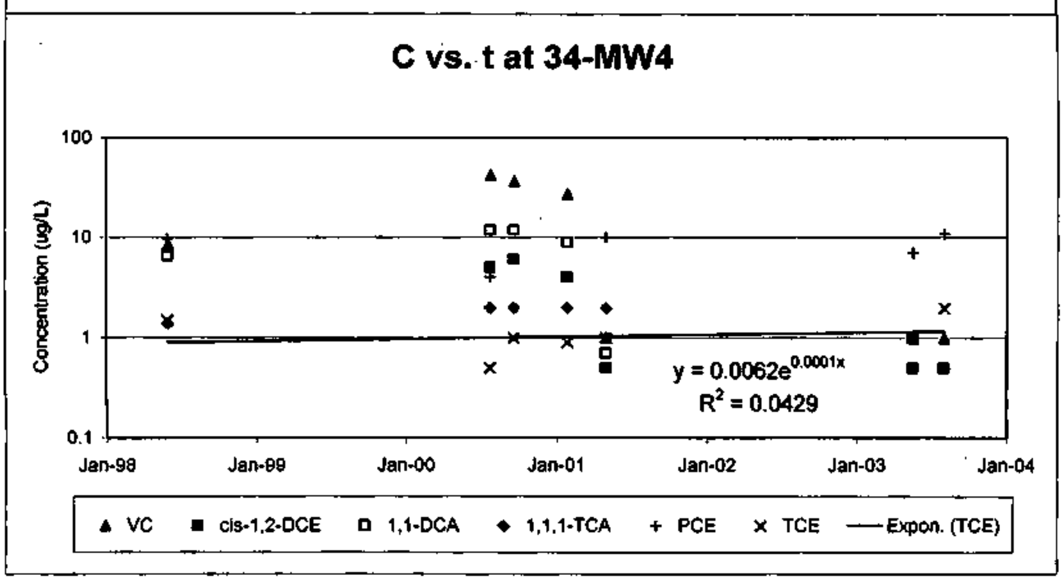


Chart 10
C vs. t at 34-MW4
Concentration (ug/L)
100
10
1
0.1
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
y = 8E+11e^-0.0007x
R^2 = 0.5245
Non-Detects
VC
cis-1,2-DCE
1,1-DCA
1,1,1-TCA
PCE
TCE
Expon. (1,1,1-TCA)


C vs. t at 34-MW4
Concentration (ug/L)
100
10
1
0.1
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
y = 0.1559e^0.0001x
R^2 = 0.024
VC
cis-1,2-DCE
1,1-DCA
1,1,1-TCA
PCE
TCE
Expon. (PCE)


C vs. t at 34-MW4
Concentration (ug/L)
100
10
1
0.1
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
y = 0.0062e^0.0001x
R^2 = 0.0429
VC
cis-1,2-DCE
1,1-DCA
1,1,1-TCA
PCE
TCE
Expon. (TCE)

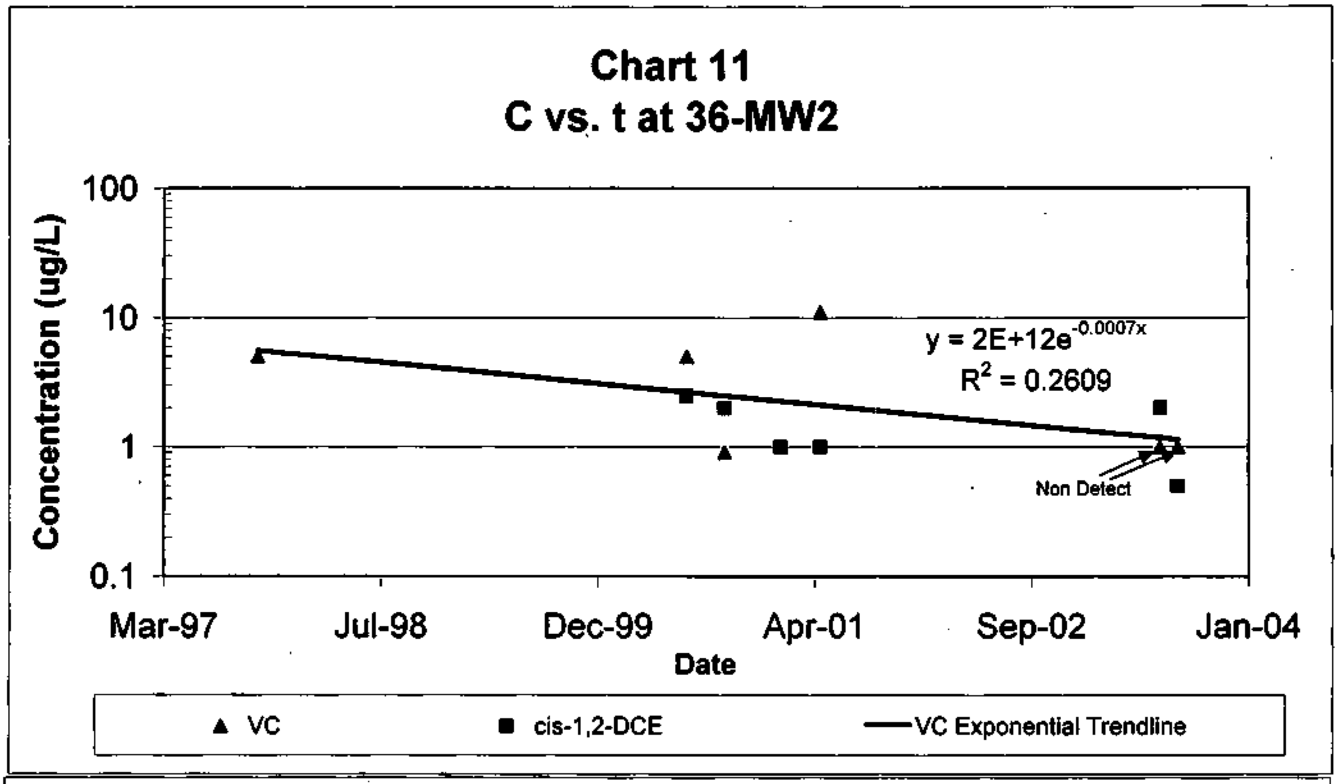
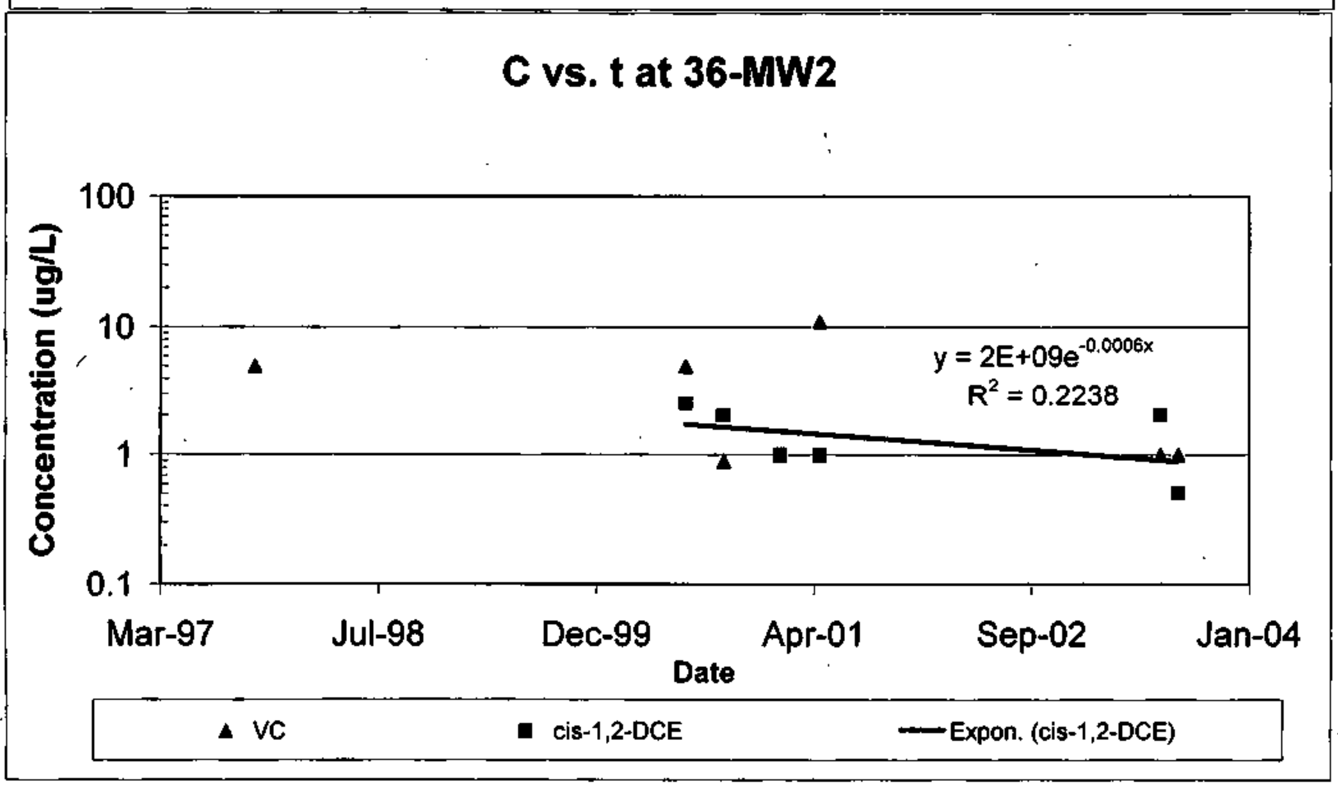


Chart 11
C vs. t at 36-MW2
100
10
1
0.1
Concentration (ug/L)
y = 2E+12e^-0.0007x
R^2 = 0.2609
Non Detect
Mar-97
Jul-98
Dec-99
Apr-01
Sep-02
Jan-04
Date
VC
cis-1,2-DCE
VC Exponential Trendline



C vs. t at 36-MW2
100
10
1
0.1
Concentration (ug/L)
y = 2E+09e^-0.0006x
R^2 = 0.2238
Mar-97
Jul-98
Dec-99
Apr-01
Sep-02
Jan-04
Date
VC
cis-1,2-DCE
Expon. (cis-1,2-DCE)

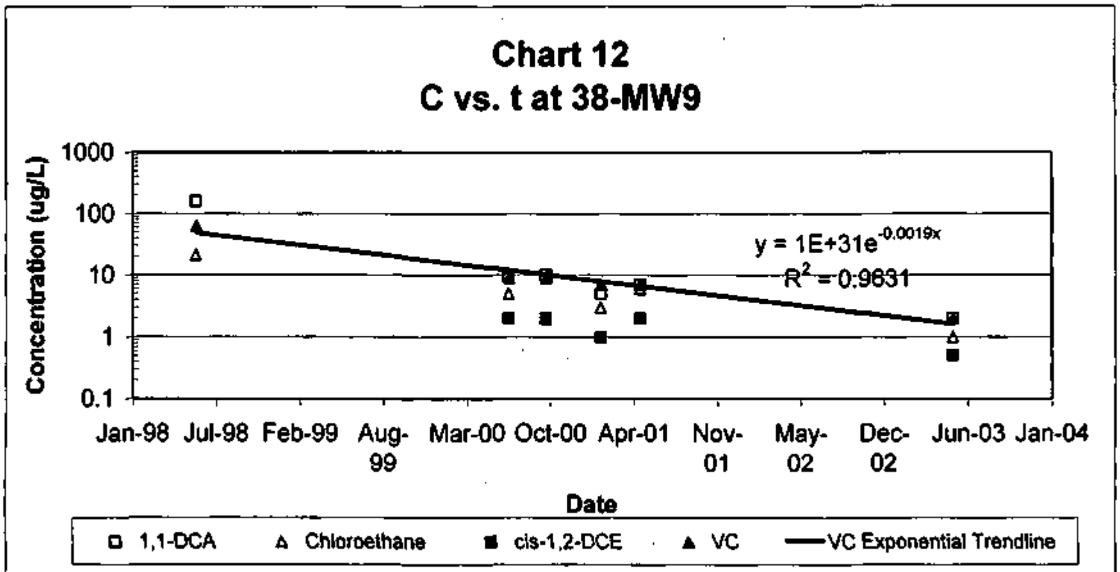
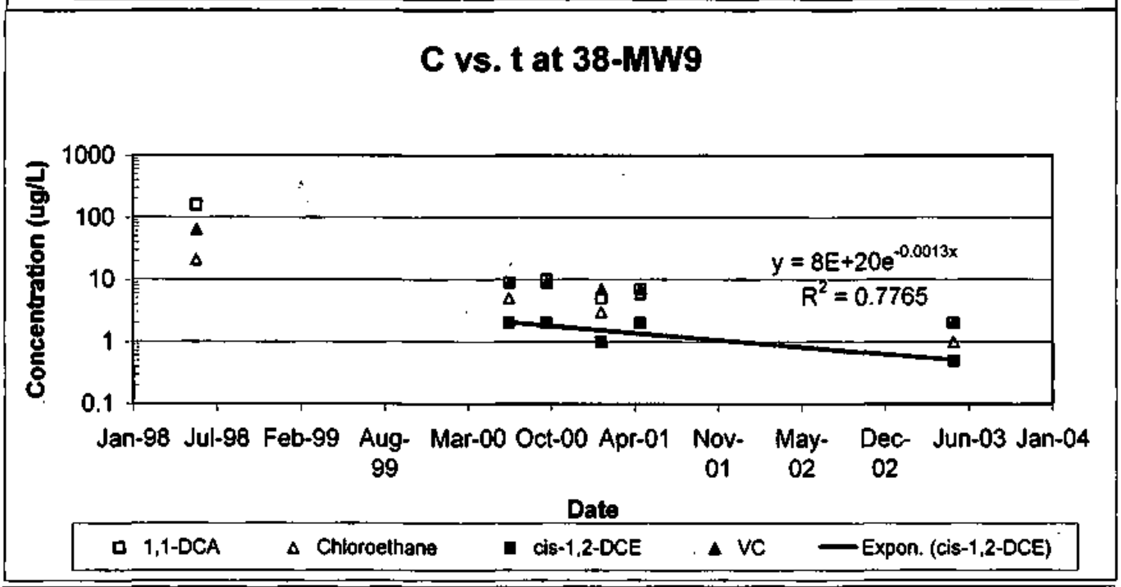
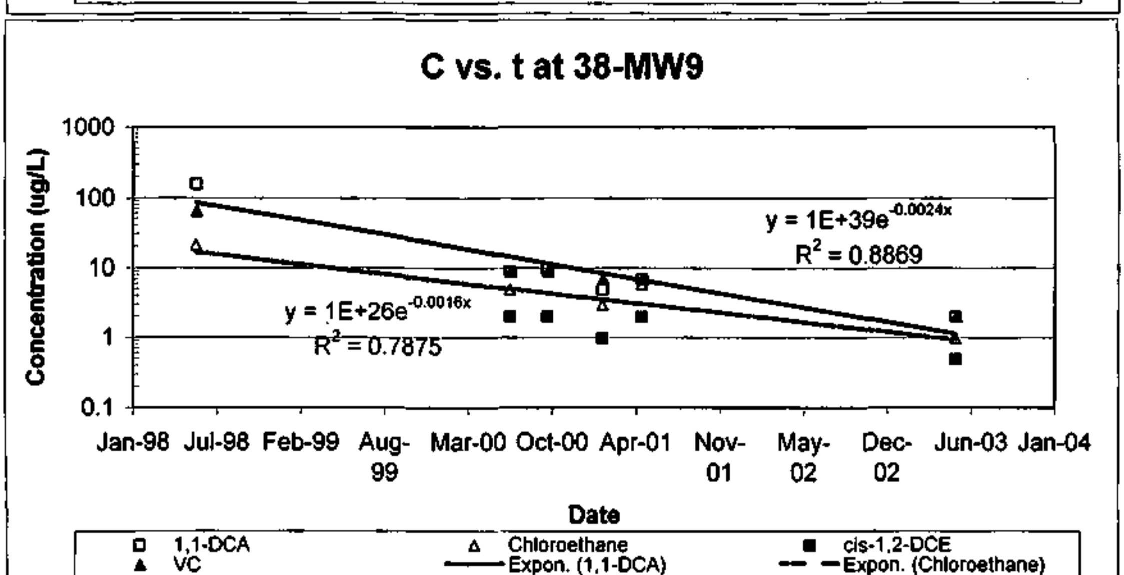


Chart 12
C vs. t at 38-MW9
Concentration (ug/L)
1000
100
10
1
0.1
y = 1E+31e-0.0019x
R2 = 0.9631
Jan-98 Jul-98 Feb-99 Aug-99 Mar-00 Oct-00 Apr-01 Nov-01 May-02 Dec-02 Jun-03 Jan-04
Date
1,1-DCA
Chloroethane
cis-1,2-DCE
VC
VC Exponential Trendline


C vs. t at 38-MW9
Concentration (ug/L)
1000
100
10
1
0.1
y = 8E+20e-0.0013x
R2 = 0.7765
Jan-98 Jul-98 Feb-99 Aug-99 Mar-00 Oct-00 Apr-01 Nov-01 May-02 Dec-02 Jun-03 Jan-04
Date
1,1-DCA
Chloroethane
cis-1,2-DCE
VC
Expon. (cis-1,2-DCE)


C vs. t at 38-MW9
Concentration (ug/L)
1000
100
10
1
0.1
y = 1E+39e-0.0024x
R2 = 0.8869
y = 1E+26e-0.0016x
R2 = 0.7875
Jan-98 Jul-98 Feb-99 Aug-99 Mar-00 Oct-00 Apr-01 Nov-01 May-02 Dec-02 Jun-03 Jan-04
Date
1,1-DCA
Chloroethane
cis-1,2-DCE
VC
Expon. (1,1-DCA)
Expon. (Chloroethane)

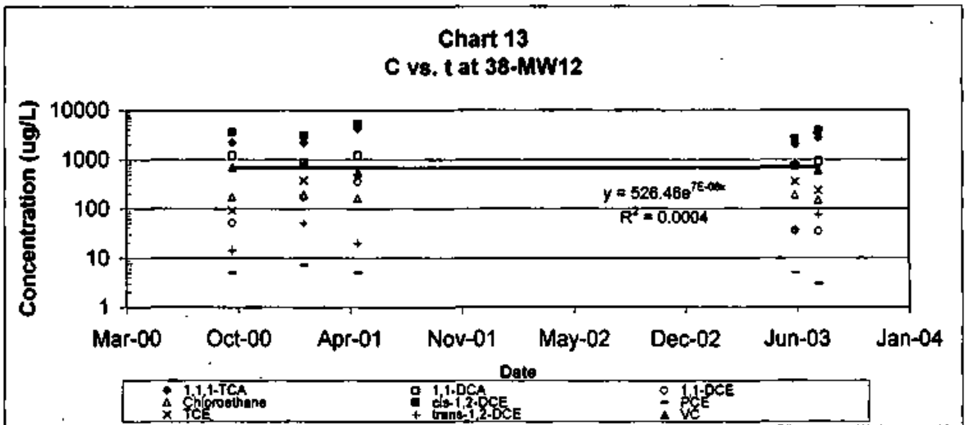
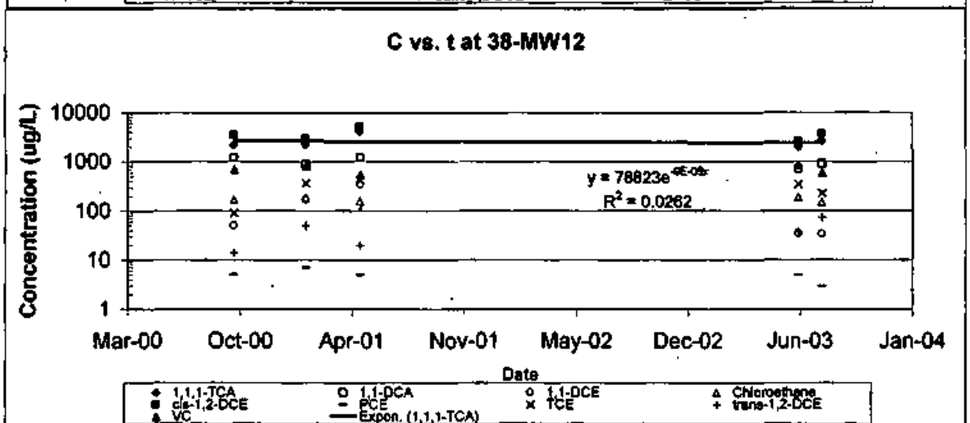
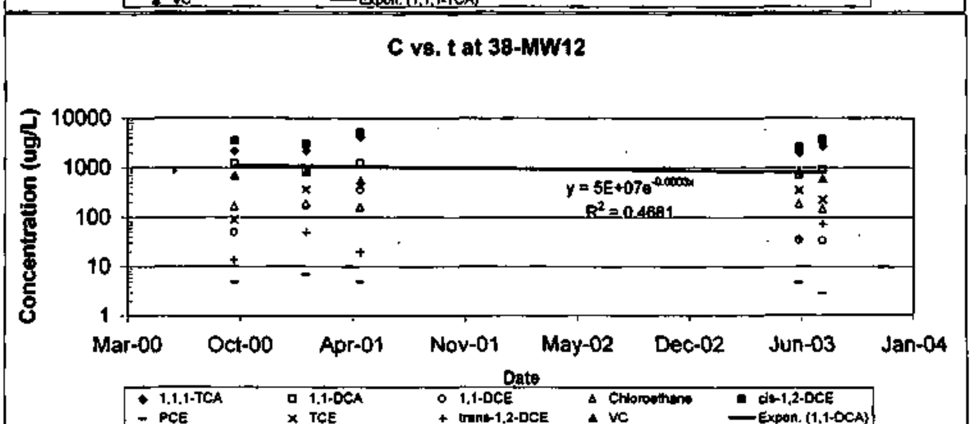


Chart 13
C vs. t at 38-MW12
Concentration (ug/L)
10000
1000
100
10
1
Mar-00
Oct-00
Apr-01
Nov-01
May-02
Dec-02
Jun-03
Jan-04
Date
y = 526.46e^7E-08x
R² = 0.0004
1,1,1-TCA
Chloroethane
TCE
1,1-DCA
cis-1,2-DCE
trans-1,2-DCE
1,1-DCE
PCE
VC


C vs. t at 38-MW12
Concentration (ug/L)
10000
1000
100
10
1
Mar-00
Oct-00
Apr-01
Nov-01
May-02
Dec-02
Jun-03
Jan-04
Date
y = 78823e^-9E-05x
R² = 0.0262
1,1,1-TCA
cis-1,2-DCE
VC
1,1-DCA
PCE
Expon. (1,1,1-TCA)
1,1-DCE
TCE
Chloroethane
trans-1,2-DCE


C vs. t at 38-MW12
Concentration (ug/L)
10000
1000
100
10
1
Mar-00
Oct-00
Apr-01
Nov-01
May-02
Dec-02
Jun-03
Jan-04
Date
y = 5E+07e^-0.0003x
R² = 0.4681
1,1,1-TCA
1,1-DCA
1,1-DCE
Chloroethane
cis-1,2-DCE
PCE
TCE
trans-1,2-DCE
VC
Expon. (1,1-DCA)

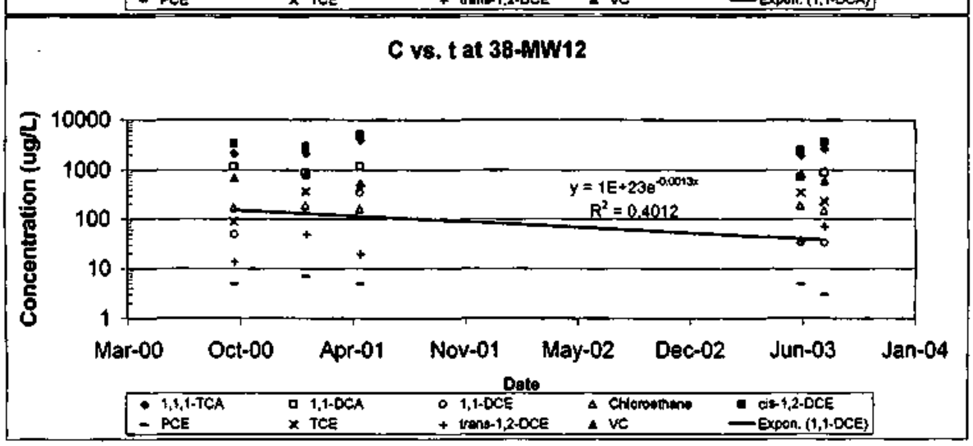
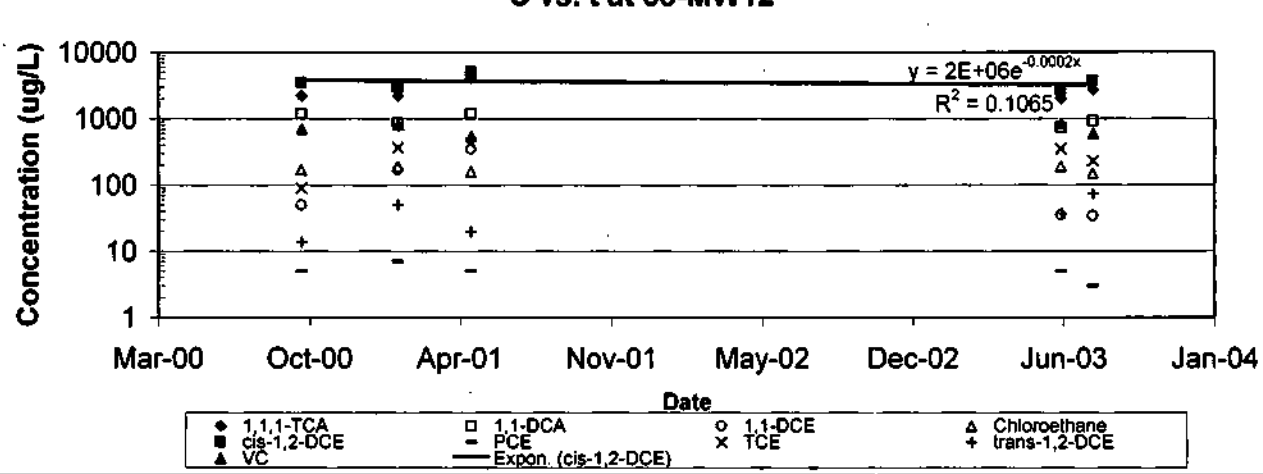
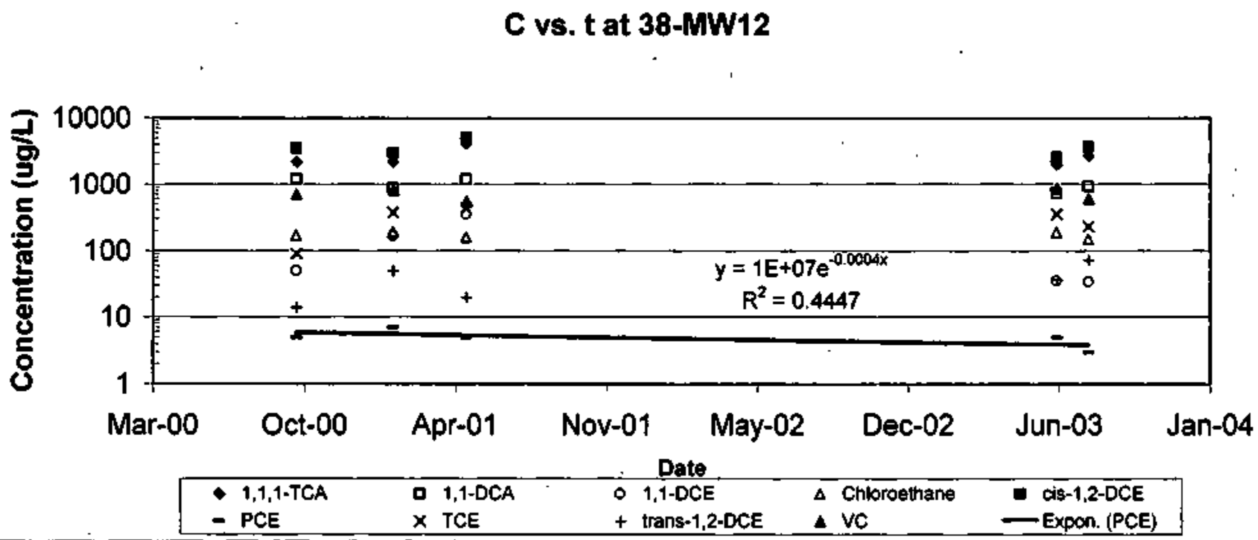
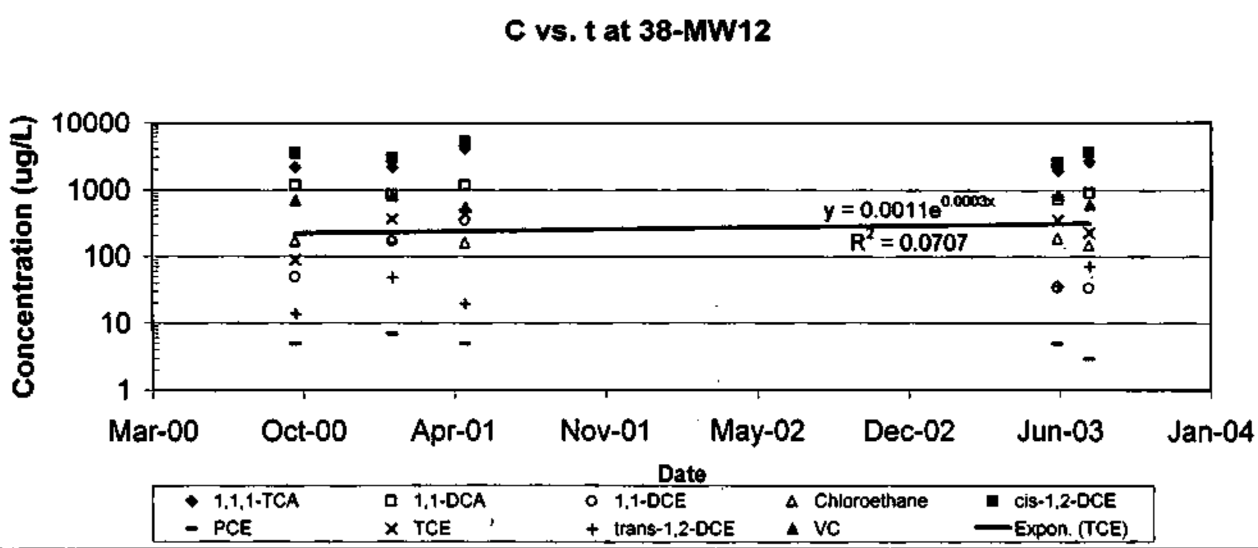

C vs. t at 38-MW12
Concentration (ug/L)
10000
1000
100
10
1
Mar-00
Oct-00
Apr-01
Nov-01
May-02
Dec-02
Jun-03
Jan-04
Date
y = 1E+23e^-0.0013x
R² = 0.4012
1,1,1-TCA
1,1-DCA
1,1-DCE
Chloroethane
cis-1,2-DCE
PCE
TCE
trans-1,2-DCE
VC
Expon. (1,1-DCE)

Chart 13


C vs. t at 38-MW12
Concentration (ug/L)
10000
1000
100
10
1
Mar-00
Oct-00
Apr-01
Nov-01
May-02
Dec-02
Jun-03
Jan-04
Date
y = 2E+06e^-0.0002x
R^2 = 0.1065
1,1,1-TCA
1,1-DCA
1,1-DCE
Chloroethane
cis-1,2-DCE
PCE
TCE
trans-1,2-DCE
VC
Expon. (cis-1,2-DCE)


C vs. t at 38-MW12
Concentration (ug/L)
10000
1000
100
10
1
Mar-00
Oct-00
Apr-01
Nov-01
May-02
Dec-02
Jun-03
Jan-04
Date
y = 1E+07e^-0.0004x
R^2 = 0.4447
1,1,1-TCA
1,1-DCA
1,1-DCE
Chloroethane
cis-1,2-DCE
PCE
TCE
trans-1,2-DCE
VC
Expon. (PCE)


C vs. t at 38-MW12
Concentration (ug/L)
10000
1000
100
10
1
Mar-00
Oct-00
Apr-01
Nov-01
May-02
Dec-02
Jun-03
Jan-04
Date
y = 0.0011e^0.0003x
R^2 = 0.0707
1,1,1-TCA
1,1-DCA
1,1-DCE
Chloroethane
cis-1,2-DCE
PCE
TCE
trans-1,2-DCE
VC
Expon. (TCE)

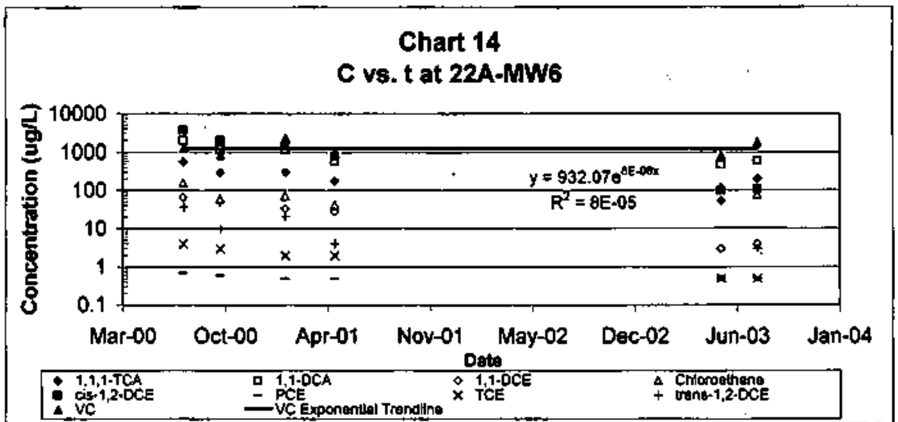
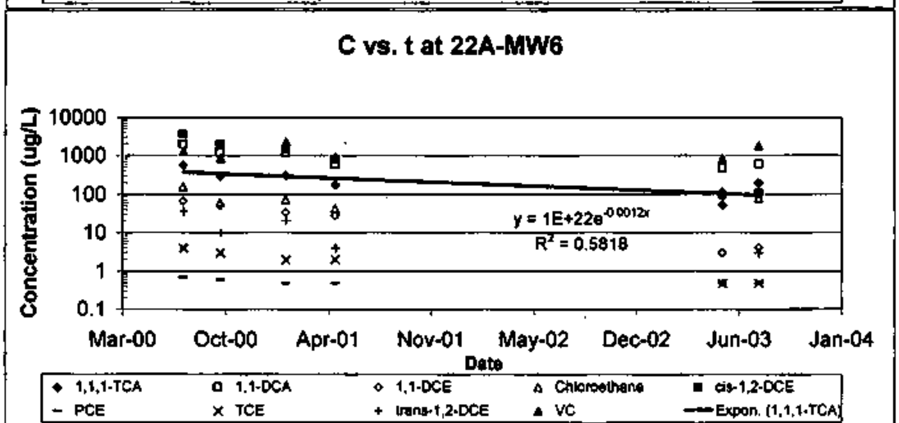
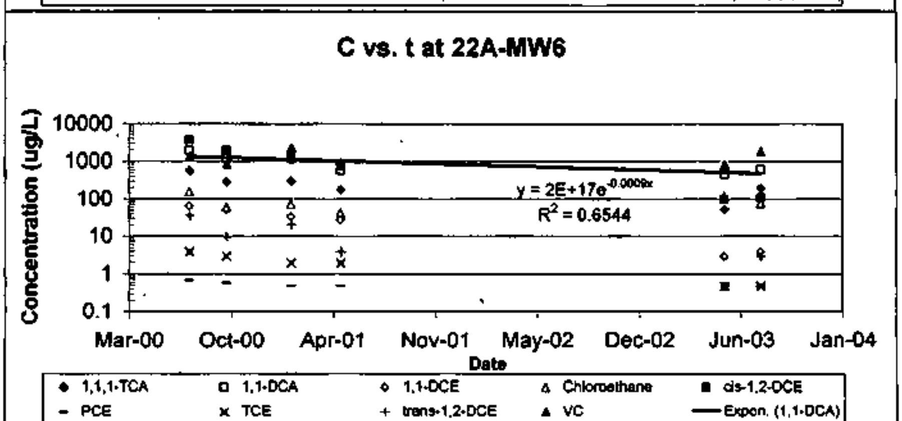
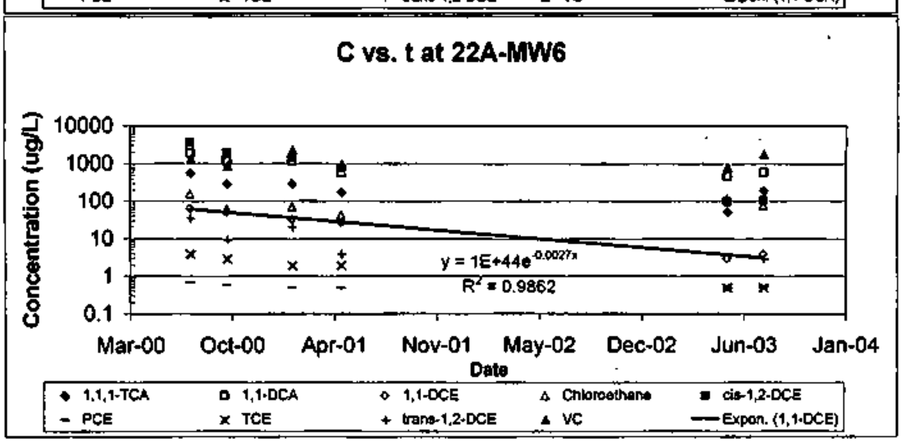


Chart 14
C vs. t at 22A-MW6
Concentration (ug/L)
10000
1000
100
10
1
0.1
Mar-00
Oct-00
Apr-01
Nov-01
May-02
Dec-02
Jun-03
Jan-04
Date
y = 932.07e^8E-06x
R² = 8E-05
1,1,1-TCA
1,1-DCA
1,1-DCE
Chloroethane
cis-1,2-DCE
PCE
TCE
trans-1,2-DCE
VC
VC Exponential Trendline


C vs. t at 22A-MW6
Concentration (ug/L)
10000
1000
100
10
1
0.1
Mar-00
Oct-00
Apr-01
Nov-01
May-02
Dec-02
Jun-03
Jan-04
Date
y = 1E+22e^-0.0012x
R² = 0.5818
1,1,1-TCA
1,1-DCA
1,1-DCE
Chloroethane
cis-1,2-DCE
PCE
TCE
trans-1,2-DCE
VC
Expon. (1,1,1-TCA)


C vs. t at 22A-MW6
Concentration (ug/L)
10000
1000
100
10
1
0.1
Mar-00
Oct-00
Apr-01
Nov-01
May-02
Dec-02
Jun-03
Jan-04
Date
y = 2E+17e^-0.0009x
R² = 0.6544
1,1,1-TCA
1,1-DCA
1,1-DCE
Chloroethane
cis-1,2-DCE
PCE
TCE
trans-1,2-DCE
VC
Expon. (1,1-DCA)


C vs. t at 22A-MW6
Concentration (ug/L)
10000
1000
100
10
1
0.1
Mar-00
Oct-00
Apr-01
Nov-01
May-02
Dec-02
Jun-03
Jan-04
Date
y = 1E+44e^-0.0027x
R² = 0.9862
1,1,1-TCA
1,1-DCA
1,1-DCE
Chloroethane
cis-1,2-DCE
PCE
TCE
trans-1,2-DCE
VC
Expon. (1,1-DCE)

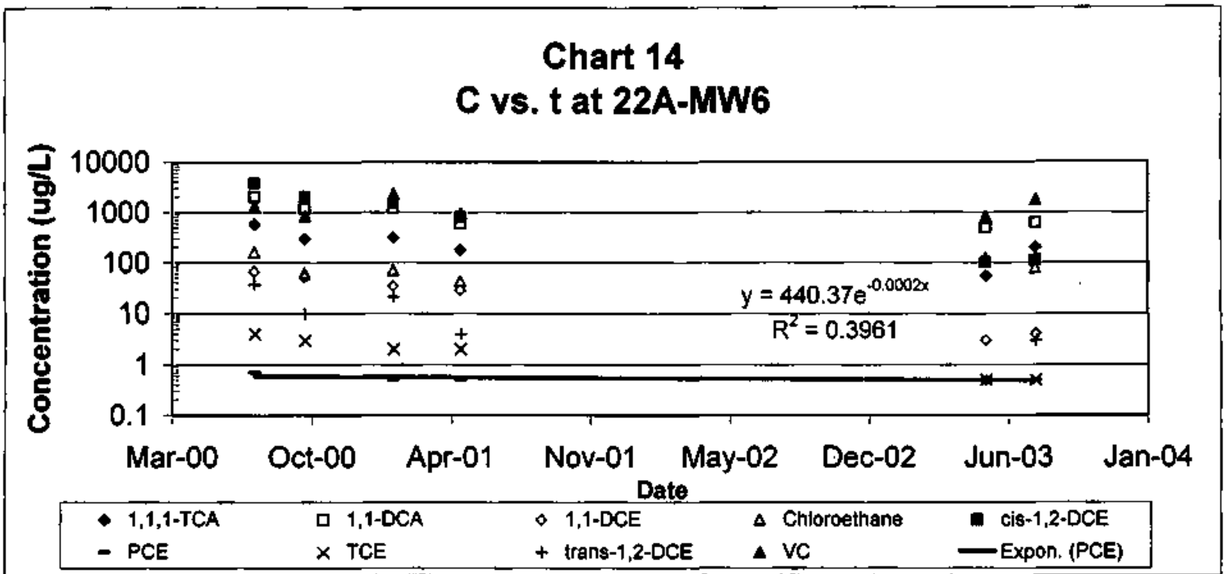
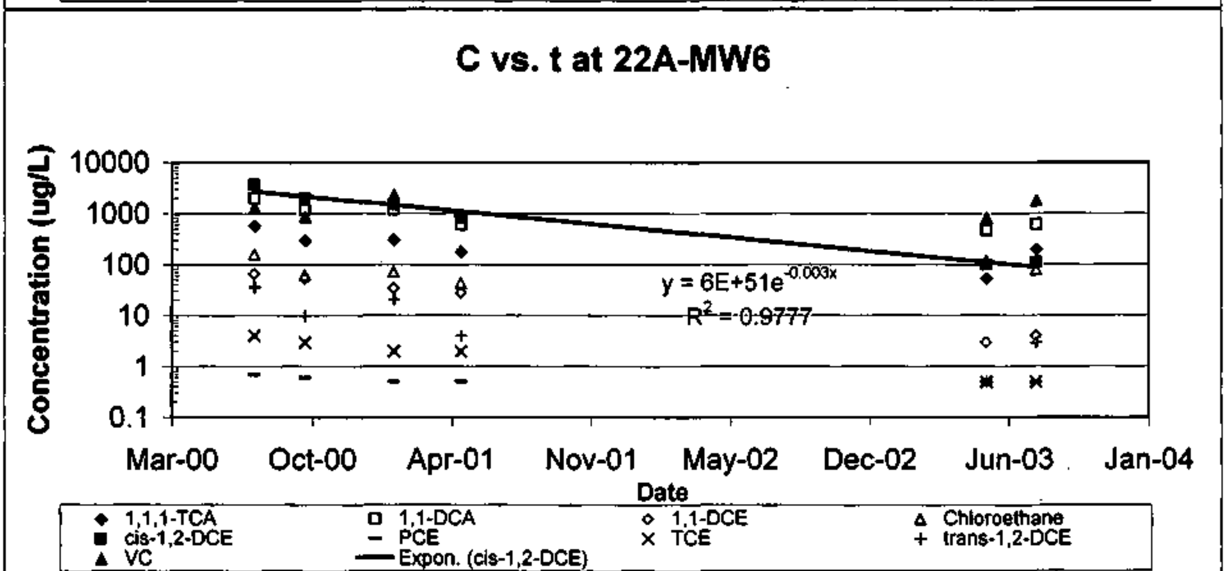
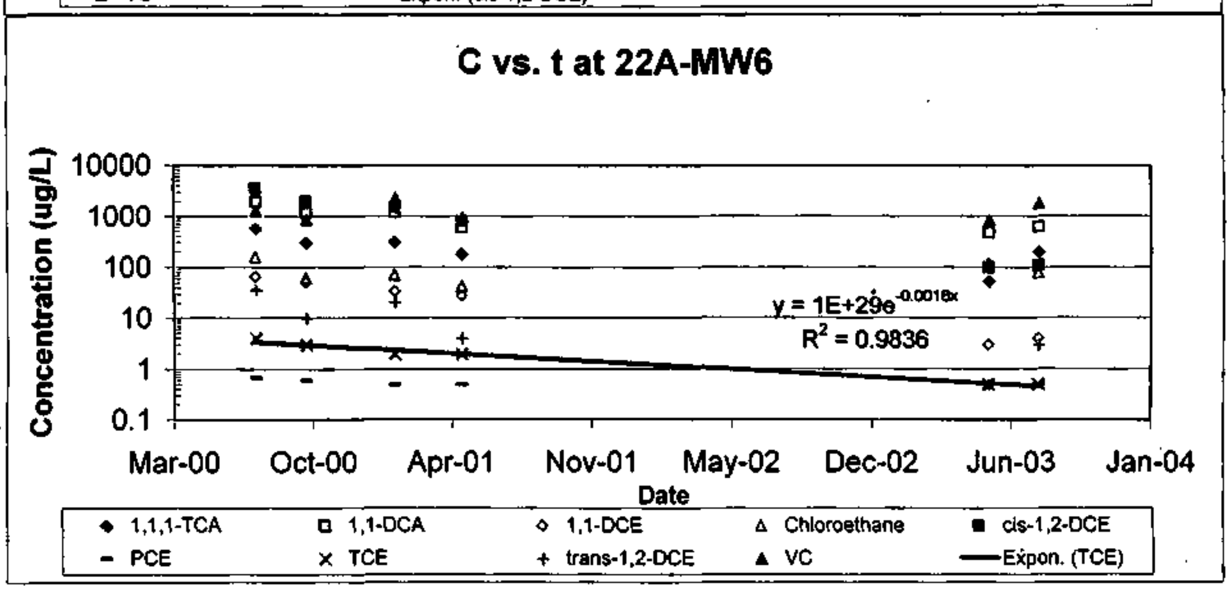


Chart 14
C vs. t at 22A-MW6
Concentration (ug/L)
10000
1000
100
10
1
0.1
Mar-00
Oct-00
Apr-01
Nov-01
May-02
Dec-02
Jun-03
Jan-04
Date
$y = 440.37e^{-0.0002x}$
$R^2 = 0.3961$
1,1,1-TCA
1,1-DCA
1,1-DCE
Chloroethane
cis-1,2-DCE
PCE
TCE
trans-1,2-DCE
VC
Expon. (PCE)

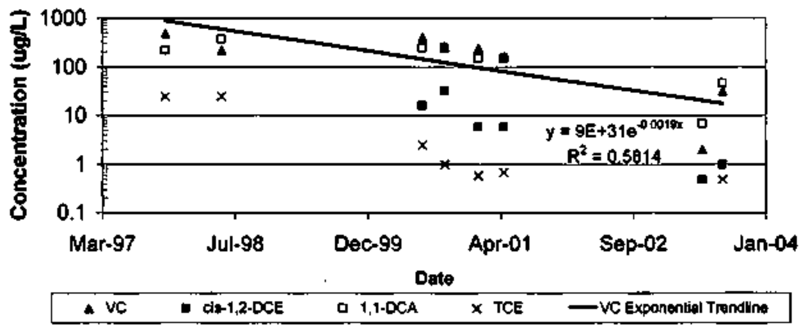


C vs. t at 22A-MW6
Concentration (ug/L)
10000
1000
100
10
1
0.1
Mar-00
Oct-00
Apr-01
Nov-01
May-02
Dec-02
Jun-03
Jan-04
Date
$y = 6E+51e^{-0.003x}$
$R^2 = 0.9777$
1,1,1-TCA
1,1-DCA
1,1-DCE
Chloroethane
cis-1,2-DCE
PCE
TCE
trans-1,2-DCE
VC
Expon. (cis-1,2-DCE)

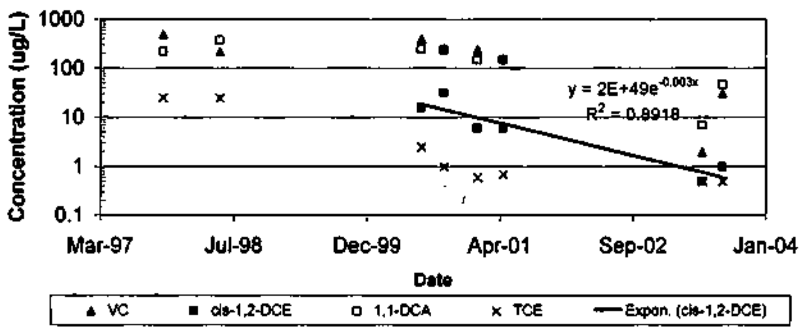


C vs. t at 22A-MW6
Concentration (ug/L)
10000
1000
100
10
1
0.1
Mar-00
Oct-00
Apr-01
Nov-01
May-02
Dec-02
Jun-03
Jan-04
Date
$y = 1E+29e^{-0.0016x}$
$R^2 = 0.9836$
1,1,1-TCA
1,1-DCA
1,1-DCE
Chloroethane
cis-1,2-DCE
PCE
TCE
trans-1,2-DCE
VC
Expon. (TCE)

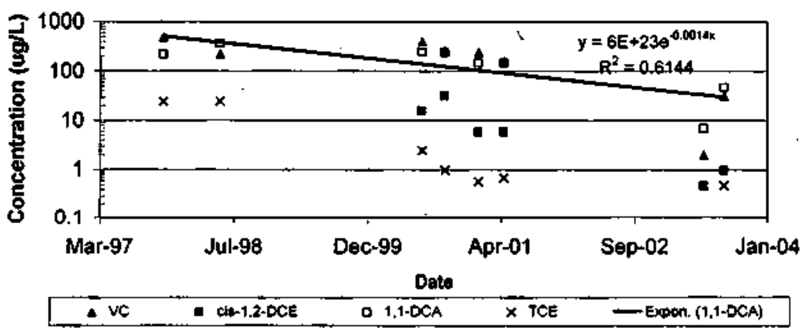
Chart 15
C vs. t at 34-MW1



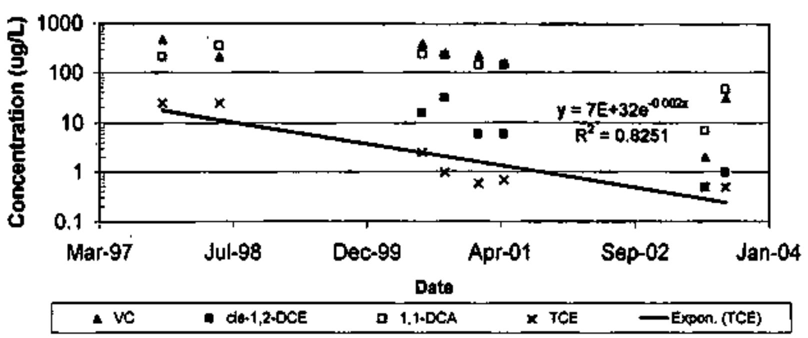
C vs. t at 34-MW1



C vs. t at 34-MW1



C vs. t at 34-MW1



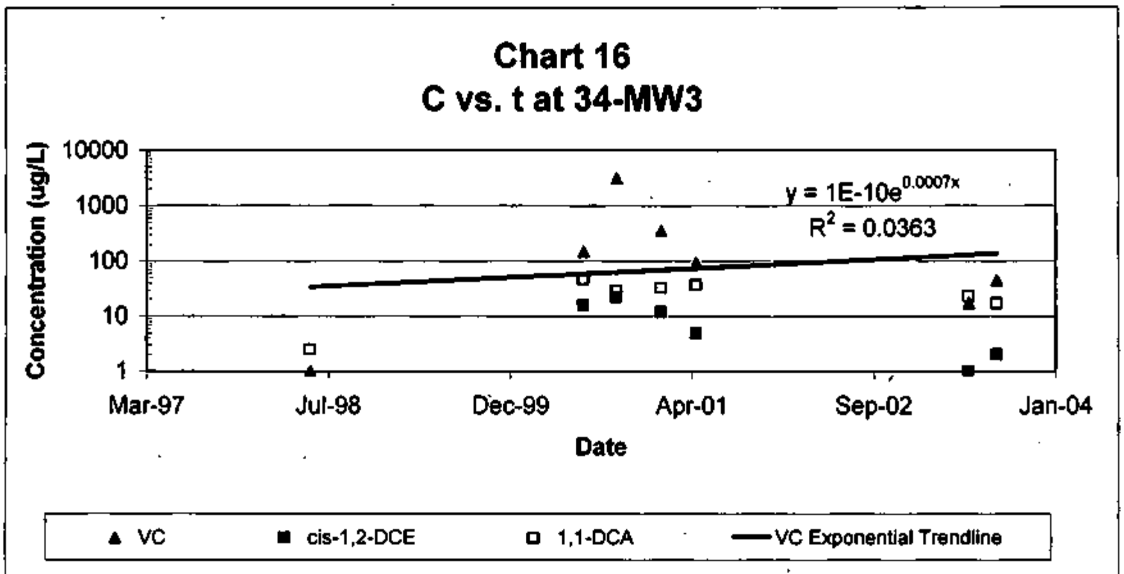
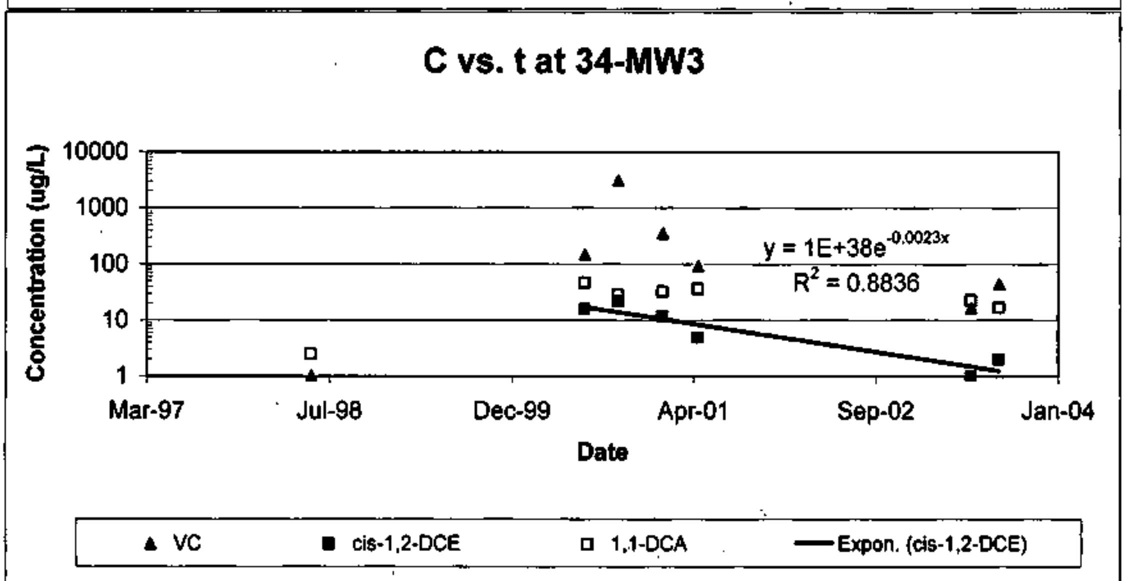
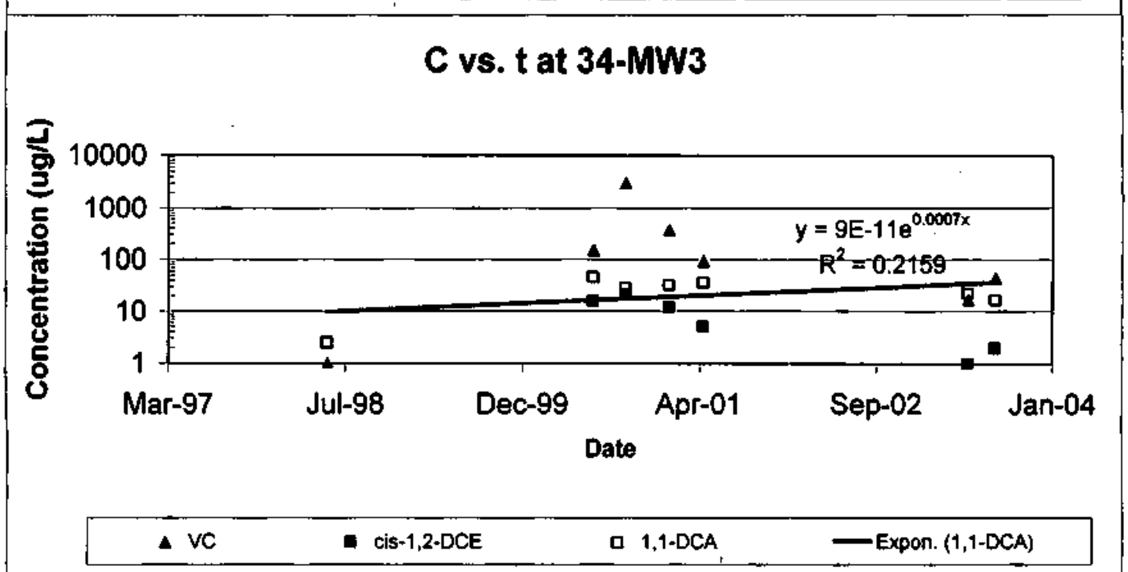


Chart 16
C vs. t at 34-MW3
Concentration (ug/L)
10000
1000
100
10
1
Mar-97
Jul-98
Dec-99
Apr-01
Sep-02
Jan-04
Date
y = 1E-10e^0.0007x
R^2 = 0.0363
VC
cis-1,2-DCE
1,1-DCA
VC Exponential Trendline


C vs. t at 34-MW3
Concentration (ug/L)
10000
1000
100
10
1
Mar-97
Jul-98
Dec-99
Apr-01
Sep-02
Jan-04
Date
y = 1E+38e^-0.0023x
R^2 = 0.8836
VC
cis-1,2-DCE
1,1-DCA
Expon. (cis-1,2-DCE)


C vs. t at 34-MW3
Concentration (ug/L)
10000
1000
100
10
1
Mar-97
Jul-98
Dec-99
Apr-01
Sep-02
Jan-04
Date
y = 9E-11e^0.0007x
R^2 = 0.2159
VC
cis-1,2-DCE
1,1-DCA
Expon. (1,1-DCA)

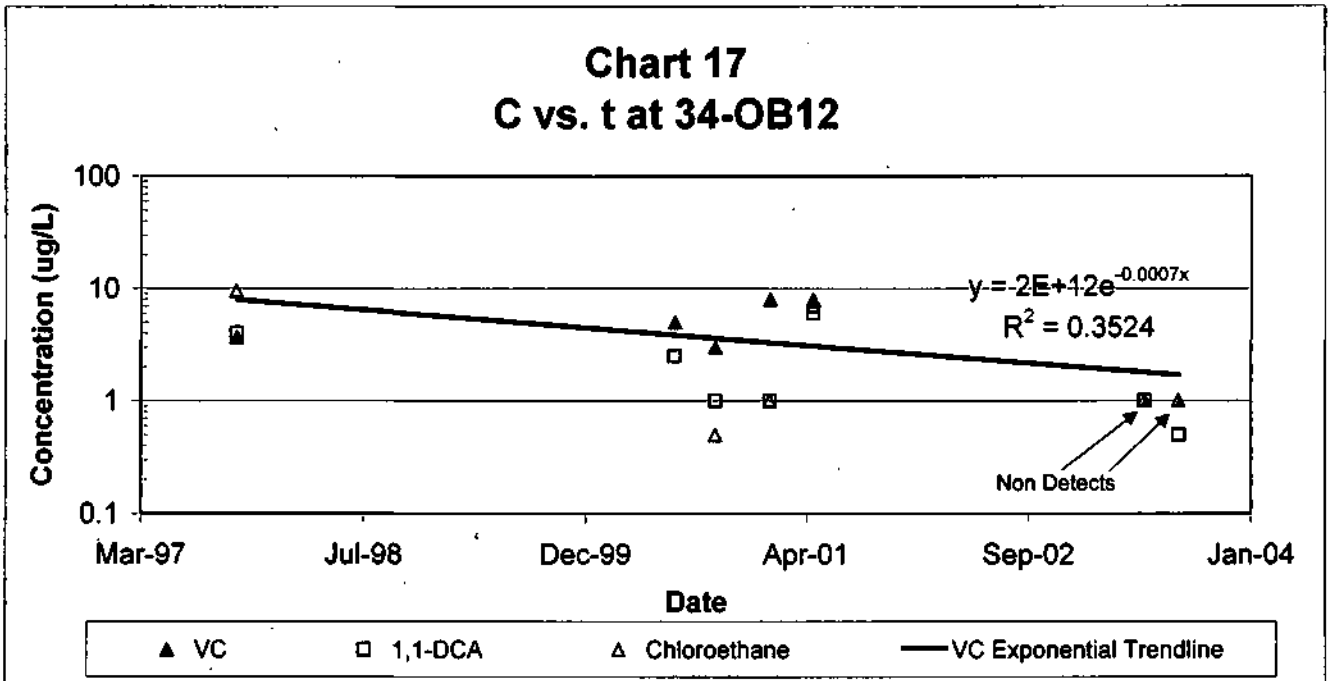
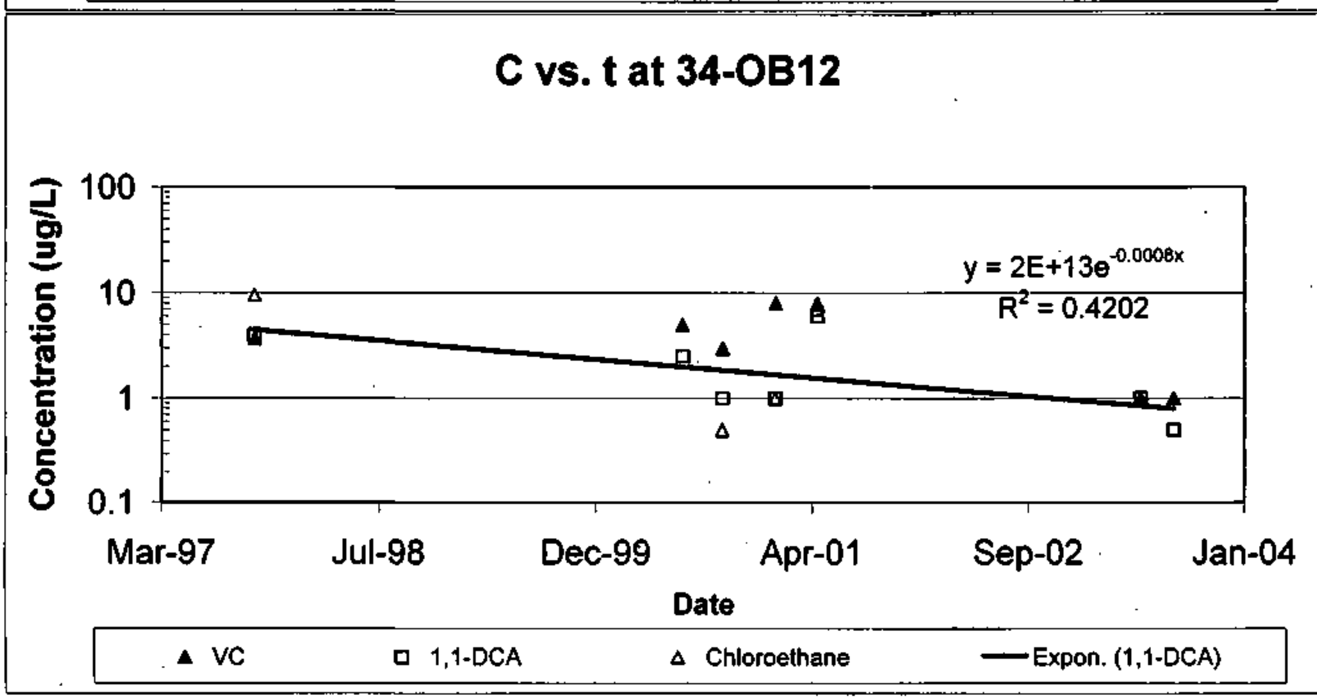


Chart 17
C vs. t at 34-OB12
100
10
1
0.1
Concentration (ug/L)
y = 2E+12e^-0.0007x
R² = 0.3524
Non Detects
Mar-97
Jul-98
Dec-99
Apr-01
Sep-02
Jan-04
Date
VC
1,1-DCA
Chloroethane
VC Exponential Trendline


C vs. t at 34-OB12
100
10
1
0.1
Concentration (ug/L)
y = 2E+13e^-0.0008x
R² = 0.4202
Mar-97
Jul-98
Dec-99
Apr-01
Sep-02
Jan-04
Date
VC
1,1-DCA
Chloroethane
Expon. (1,1-DCA)

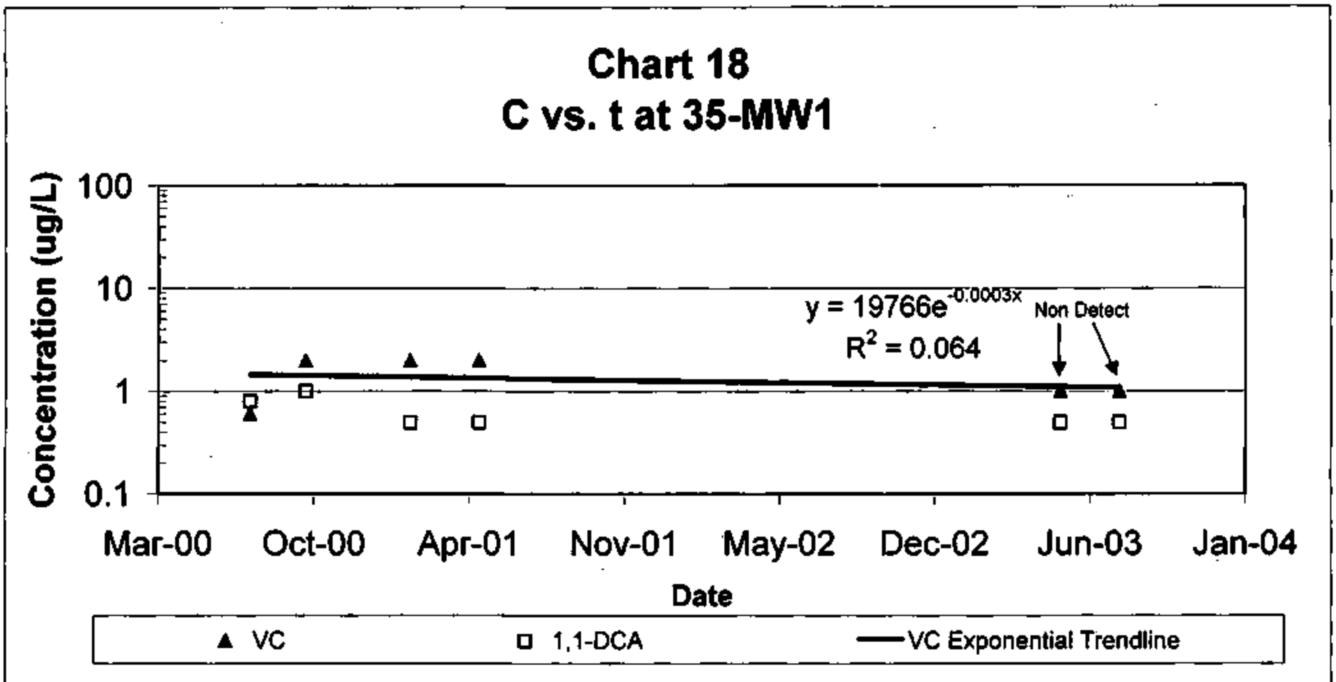
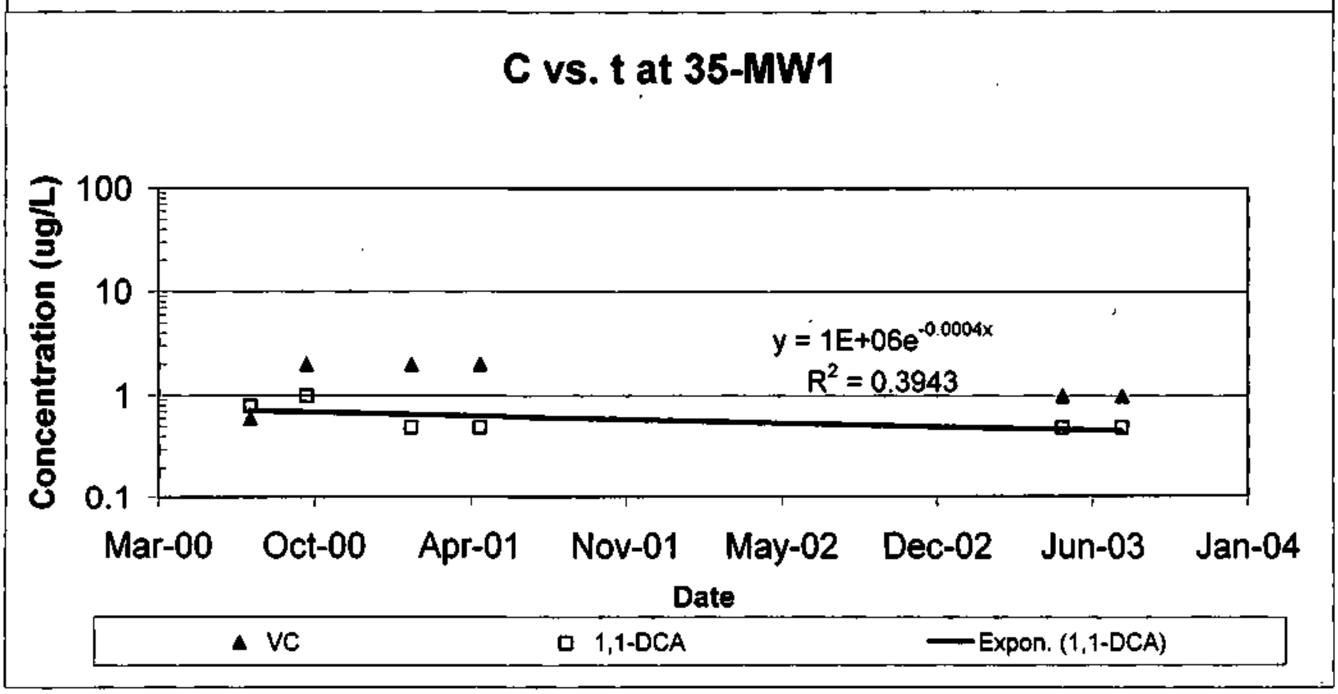


Chart 18
C vs. t at 35-MW1
Concentration (ug/L)
100
10
1
0.1
y = 19766e^-0.0003x
R^2 = 0.064
Non Detect
Mar-00
Oct-00
Apr-01
Nov-01
May-02
Dec-02
Jun-03
Jan-04
Date
VC
1,1-DCA
VC Exponential Trendline


C vs. t at 35-MW1
Concentration (ug/L)
100
10
1
0.1
y = 1E+06e^-0.0004x
R^2 = 0.3943
Mar-00
Oct-00
Apr-01
Nov-01
May-02
Dec-02
Jun-03
Jan-04
Date
VC
1,1-DCA
Expon. (1,1-DCA)

MEMORANDUM

THE FORRESTER GROUP
INSIGHTFUL ENVIRONMENTAL SOLUTIONS™

Date: October 29, 2003

To: File

From: Jay Hoskins

Subject: UPRR Ogden Rail Yard
USEPA Natural Attenuation Protocol Steps 1-7

This memorandum briefly describes how steps 1-7 of the USEPA Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater (1998) was completed. Step 8 (preparation of a long-term monitoring and verification plan for the site) is discussed in Section 6.2.2.

STEP 1: Review available site data and develop a preliminary site conceptual model.

This step was completed as part of the remedial investigation and is discussed in the RI Report.

STEP 2: Initial Site Screening

To proceed from the initial site screening step, two questions must be answered affirmatively.

> *Has the plume moved a shorter distance than would be expected?* This question is answered "yes". The basis for this answer is presented in Section 5 of the Rail Yard RI Report.
>
> *It is likely that VC is attenuating at rates sufficient to meet remediation objectives in a time period that is reasonable to other alternatives?* The answer to this question is assumed to be "yes" because analysis of concentration vs. time data indicates that fairly rapid attenuation of the northern and southern plumes is occurring. A more detailed response to this question is presented in Section 7.1.

STEP 3: Perform Additional Site Characterization Data to Further Evaluate Natural Attenuation

Natural attenuation data has been collected during three phases.

Phase I. During the Phase I investigation, groundwater samples were collected and analyzed for CVOCs. Water samples were also collected from sewer lines that run beneath the site and below the water table. Groundwater samples were used to delineate the extent of groundwater impacts. Sewer water samples indicated that a potential source of groundwater contamination could be the sewer lines that run between AOI-38 and the former AOI-34 wastewater treatment facility. The results of this work are discussed in detail in the Phase I report.

Phase II. The Phase II investigation consisted of an evaluation for the potential of chlorinated solvent DNAPL as a source of the north plume and monitoring well sampling for CVOC and geochemical parameters. Chlorinated solvent DNAPL was not found in the site, and if DNAPL exists, it is likely in pockets that defy practical delineation efforts. Monitoring well data indicate that neither plume is expanding: the north plume is at steady-state and the south

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812 Swifts Highway, Jefferson City, MO 65109, p 573.634.8109, f 573.634.8224
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plume may be shrinking. Geochemical parameters indicated that geochemical conditions in the north plume are sufficient for reductive dechlorination of VC.

Feasibility Study Investigation. Key north and south plume monitoring wells were sampled in May/June and August 2003. All of the wells were sampled for CVOCs; some were also sampled for ethene, ethane, and methane. Analysis of this data is discussed in Appendix D. Site data indicate that south plume concentrations are decreasing and the plume is likely shrinking. The north plume is not expanding, and concentrations in some wells appear to be decreasing. Concentration data for the north plume wells with the highest total CVOC concentration remain steady over time, indicating that the plume concentrations near the source of groundwater impacts are not changing.

STEP 4: Refine Conceptual Model, Complete Pre-Modeling Calculations, and Document Indicators of Natural Attenuation.

The main points of the conceptual model are:

- Ingestion of north or south plume groundwater is not currently a complete exposure pathway.
- Aqueous phase VC is a result of natural attenuation processes that are reductively dechlorinating TCE, 1,1,1-TCA, and/or PCE.
- Diesel LNAPL is driving redox conditions to methanogenic levels capable of producing VC from these compounds.
- A clear source of chlorinated solvents has not been found. CVOCs likely exist in three phases:
    - Aqueous phase (groundwater)
    - Sorbed phase (soil or pipe sludge)
    - Pockets of DNAPL (above the Alpine Clay or in pipe sludge).
- Based on the concentration vs. time trend analysis shown in Appendix B, data suggest that the north plume is not increasing in extent. The north plume monitoring wells with the highest levels of dissolved phase CVOCs have steady state concentrations of CVOCs., and downgradient wells have shown signs of decreasing CVOC concentrations (i.e., plume shrinkage).
- In the south plume, concentrations of VC and its parent CVOCs appear to be decreasing over time. Based on this trend, the southern CVOC plume may be shrinking.
- VC has not been detected in either the Weber River or the 21st Street Pond, which are the closest surface water bodies. If the northern plume was to migrate it would discharge to the 21st Street Pond, a local groundwater sink.

An analysis of VC degradation rates was presented in Appendix O of the RI report. Based on this analysis, the biodegradation half-life of VC is estimated to be between 12-62 days.

The analysis of natural attenuation indicator data is discussed in Section 5 of the Rail Yard RI report and is refined in Appendix D. Based on the natural attenuation indicator data, there is strong evidence for reductive dechlorination at the site.

STEP 5: Simulate Natural Attenuation Using Fate and Transport Models

The northern VC plume was analyzed using Natural Attenuation Software (NAS) v. 1.2.2. NAS modeling work is presented in Appendix B. Results are summarized below:

- The length of time required to cleanup groundwater varies linearly with source mass. Larger source masses require a longer remediation time that smaller ones.

- Removing the sources of CVOCs decreases the amount of time required by natural attenuation processes to achieve aqueous phase criteria. However, because the total amount of source is difficult to quantify, the effect of source removal is uncertain. Calculations indicate that the remediation time could be a decade, but this estimate is very uncertain because the total mass of CVOCs is very uncertain.

- Partial source removal improves the time required to restore the aquifer in the long-term, however partial source removal does little to improve near-term groundwater quality. Virtually all source material would need to be removed before meaningful improvements in near-term groundwater quality are achieved.

STEP 6: Identify Potential Receptors and Exposure Points and Conduct an Exposure Pathway Analysis.

This step was completed and documented in the Baseline Human Health Risk Assessment, Baseline Human Ecological Risk Assessment, RI Report, and Vapor Phase Pathway Investigation.

- Ingestion of plume groundwater would be of concern if this pathway was complete; however, groundwater ingestion is not a complete pathway. In order to address future groundwater ingestion, an institutional control could be applied to the site. Details on such an IC are provided in Appendix F.

- Vapor phase sampling was performed in the remedial investigation and feasibility study phases of this project, and results indicate that the CVOC plumes do not pose an elevated vapor phase risk.

- The discharge point for rail yard groundwater is the 21st Street Pond, and exposure there is the most likely complete exposure pathway. However VC has not been detected in the Pond, indicating that the groundwater does not pose an unacceptable risk. Given that VC has not been detected in the pond and concentration vs. time data indicates that plume expansion is unlikely, VC is unlikely to pose a future risk to the Pond.

STEP 7: Evaluate the Need for Supplemental Source Control Measures

In its directive on MNA, USEPA states, *"Control of source materials is the most effective means of ensuring the timely attainment of remediation objectives. EPA, therefore, expects that source control measures will be evaluated for all contaminated sites and that source control measures will be taken at most sites where practicable."*

A positive source of groundwater impacts has not been identified. Alternative 3 (partial source removal) and Alternative 4 (aggressive source removal) evaluate source control measures.

APPENDIX F
ACL PETITION

MEMORANDUM

THE FORRESTER GROUP
INSIGHTFUL ENVIRONMENTAL SOLUTIONS℠

Date: September 13, 2004

To: File

From: Jay Hoskins

Subject: Preliminary Determination of Alternate Concentration Limits for Chemicals of Concern at the UPRR Ogden Rail Yard

CERCLA Section 121(d)(2)(B)(ii) provides for the establishment of alternative concentration limits (ACLs) for groundwater that may be used instead of those that are otherwise applicable (maximum concentration limits and maximum concentration limit goals). An ACL for groundwater may not be established if a point of human exposure is assumed to exist beyond the boundary of a facility except where the following three criteria are met:

1. There are known and projected points of groundwater entry into the surface water.

2. On the basis of measurements or projections, there is or will be no statistically significant increase of such constituents from such groundwater in such surface water at the point of entry or at any point where there is reason to believe accumulation of constituents may occur downstream.

3. The remedial action includes enforceable measures that preclude exposure to groundwater at any point between the facility boundary and all known and projected points of entry of such groundwater into surface water.

EPA considers ACLs appropriate only when restoration to ARAR or risk-based levels is not practicable and a site-specific analysis demonstrates that the above three conditions for use of ACLs are met.

The nearest points of human exposure are at the site surface water bodies (the 21st Street Pond, the Weber River, and the Ogden River), none of which are on rail yard property (i.e., off-site). Therefore, the three criteria are applicable to the UPRR Ogden Rail Yard facility. The approach used to recommend ACLs at the UPRR Ogden Rail Yard first examines whether the Site meets the three criteria. Once it has been determined that the three criteria are satisfied, then site-specific ACLs are developed.

Evaluation of CERCLA ACL Criteria

Criterion 1. There are known and projected points of groundwater entry into the surface water.

An evaluation of the ultimate discharge point of the northern and southern vinyl chloride plumes (associated with the Rail Yard) and the PAH/Benzene/Ethylbenzene plume (associated with the Northern Area DNAPL) was performed (Attachment A). The evaluation concluded that the ultimate groundwater discharge point at the site, including the areas that currently contain the two vinyl chloride plumes is the 21st Street Pond. Base on flow paths and groundwater elevation maps, groundwater in the vicinity of both the North Plume and South Plume ultimately migrates toward the 21st Street Pond. The more limited actual extent of the plumes is due to natural attenuation processes. Additionally, this conclusion is

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consistent with the Remedial Investigation (RI) Report's finding that, in general, the 21st Street Pond acts as a sink for groundwater flow. Therefore, site conditions satisfy Criterion 1.

Criterion 2. On the basis of measurements or projections, there is or will be no statistically significant increase of such constituents from such groundwater in such surface water at the point of entry or at any point where there is reason to believe accumulation of constituents may occur downstream.

A significant increase in concentrations would be an exceedance of surface water quality criteria. The recommended groundwater ACLs will be a level that, at the point of compliance, does not result in an exceedance of surface water quality criteria under normal groundwater discharge conditions. The point of compliance monitoring wells would be monitoring wells closest to the 21st Street Pond where impacted groundwater could potentially discharge. Periodic surface water sampling would also be performed to confirm that pond levels remain below these criteria.

Pond water sampling during the RI has not detected site constituents of concern in the 21st Street Pond, Weber River, or the Ogden River. Thus, background levels of site constituents of concern (COCs) in surface water appear to be below the analytical detection limits used to analyze these samples.

Criterion 3. The remedial action includes enforceable measures that preclude exposure to groundwater at any point between the facility boundary and all known and projected points of entry of such groundwater into surface water.

All of the remedial alternatives for which ACLs would be applied include institutional controls to preclude groundwater exposure. Example institutional controls are provided in Appendix F-Example Institutional Controls of the FS. Thus, Criterion 3 is met.

Summary

Based on the above discussion, site conditions already meet Criterion 1 and 3. Criterion 2 can be achieved by establishing ACLs that meet the elements of this criterion. Therefore, ACLs were developed for this site.

Development of ACLs

General Requirements

To establish ACLs, two points must be defined: the point of compliance (POC) and the point of exposure (POE). The POC is the "vertical surface" where the monitoring takes place and the groundwater standard is set. As discussed above, the POE is the 21st Street Pond. The Pond is assumed to be completely mixed body of water, where constituent concentrations are the same throughout.

For the vinyl chloride plumes, the POC would be established at 35-MW1, the most downgradient well near where plume groundwater discharges to the 21st Street Pond. The ACLs that are presented herein are based on a level of anticipated attenuation that would occur in the Pond, as well as dilution that would occur as groundwater discharges to the Pond. Compliance with ACLs would be demonstrated by comparing ACLs to groundwater concentrations, and Pond sampling would also be performed to confirm that Pond concentrations are below surface water criteria.

For the groundwater that is impacted by DNAPL zone constituents, the POC could be established in wells located at the pond edge. The wells nearest to the pond edge would provide the best location to evaluate whether the groundwater quality meets the ACL criteria. The well pair 33-MW6/6FP is the closest well pair to the eastern edge of the pond. An average groundwater concentration based on data from this well pair would be compared to the ACL criteria to demonstrate compliance.

Part 1 of the ACL Guidance Document (1987) states that establishment of ACLs should not allow groundwater plumes to increase in size or concentration. Additional site-wide groundwater monitoring would be performed to detect shifts in plume extent or concentration. This type of monitoring would occur with all the remedial alternatives, except the No Action alternatives.

Part 1 of the ACL Guidance Document also states that ACLs should not be established so as to contaminate off-site groundwater above allowable health or environmental exposure levels. Based on the understanding of fate and transport of site groundwater impacts, no additional properties would be impacted after ACLs are established.

Additionally, the ACL Guidance Document states that if a contaminant is left in useable groundwater above a health/exposure level (as with an attenuation argument), the post-closure care period may be extended beyond 30 years. Based on this statement, post-closure care and groundwater monitoring at the site would be discontinued only after successfully demonstrating that all groundwater is safe (i.e., meets MCLs). Monitoring and IC restrictions would continue as long as COCs are present at concentrations above MCLs.

Identification and Distribution of COCs

The COCs in the rail yard groundwater are primarily chlorinated volatile organics, particularly vinyl chloride. The COCs in groundwater over the DNAPL zone are benzene, ethylbenzene, and a variety of PAHs, including carcinogenic PAHs (e.g., benzo(a)pyrene, benzo(a)anthracene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene). Table 1 summarizes the maximum detected concentration of these COCs at the recommended POC wells and the 21st Street Pond.

Figure 1 shows the extent of chlorinated organics near the Pond. As shown, groundwater samples taken in AOI-38, -22a, and -34 indicate elevated levels of a variety of chlorinated organics. Downgradient of these AOIs between these AOIs and the Pond, COC concentrations are generally below site screening levels. In fact, only vinyl chloride has been detected above its site screening level value at the downgradient end of the plume (35-MW1, the recommended POC). Using conservative assumptions, it is possible that vinyl chloride may migrate to the Pond in the future and discharge in a narrow zone.

Figures 2, 3, and 4 show the extent of dissolved phase PAHs, benzene, and ethylbenzene (respectively) at the Northern Area OU. Based on the data that have been collected, DNAPL constituents appear to be discharging to the Pond. The well pair (and recommended POC) 33-MW6/6FP is located along the southeastern edge of the Pond, near the edge of where these figures suggest an impacted groundwater discharge exists.

Pond Water Criteria

Surface water quality criteria are those defined by the State of Utah in Utah Administrative Code (UAC) R317-2. The 21st Street Pond is not specifically listed in the Code as a water of the state. However, considering that the Pond effluent is a tributary (i.e., a hydraulically connected waterway) of the Ogden River, criteria for the Ogden River apply.

The Pond effluent is a tributary to Ogden River along the stretch of the Ogden River between the Weber River confluence and the Pineview Dam. This section of the river is protected as a class 2B (secondary contact recreation), class 3 (Protected for use by aquatic life, including cold water species of game fish and other coldwater aquatic life), and class 4 (agricultural uses) surface water. A summary of water quality criteria is shown in Table 2, including recommended levels for developing ACLs. While some criteria are below the analytical detection limits used for previous pond water samples, the baseline risk assessment did not identify pond water as a risk to human health or the environment.

Calculations

ACLs were calculated by performing a mass balance on each COC that is discharged to the Pond. The mass balance model that was used is graphically illustrated in Figure 5.

- There are three influent sources of water into the pond: impacted groundwater, non-impacted groundwater, and Ogden River water that flows into the Pond through the sluice gate.
- Inside the Pond, attenuation mechanisms (e.g., volatilization and biodegradation) degrade contaminants.
- Water flows out of the Pond through a single effluent source, the sluice gate at the western edge of the Pond.

The mathematical model used to develop the ACLs is a simple mixing model. The mathematical equation that was used is shown in Table 3. General assumptions about model input parameters are the following.

- The Pond is assumed to be completely mixed and at steady-state.
- Background concentrations in the Ogden River are assumed to be below detectable values. (Three upstream samples were analyzed and COCs were not detected.) Therefore, background concentrations are assumed to be negligible. For vinyl chloride, background concentrations in the Ogden River and in groundwater are assumed to be half of their detection limit. For the hydrocarbons, these COCs are assumed to not be present.
- Appendix L of the RI Report-Part 2 estimates groundwater flow to the 21st Street Pond. The estimated groundwater flux into the pond during typical Pond levels is estimated to be 620 gpm. Lower pond levels could increase the hydraulic gradient of groundwater into the Pond, which would increase the total flux of groundwater into the Pond. Alternatively, higher pond levels would lower the groundwater flux into the Pond. A sensitivity analysis was performed on groundwater flux into the pond to examine this effect.

- Independent of the pond level, the ratio of impacted to unimpacted groundwater is assumed to be constant.

- Estimates of DNAPL impacted groundwater rates are provided in Appendix N of the RI Report-Part 2. Based on this modeling, the impacted groundwater inflow rate over the DNAPL zone during period of typical Pond levels is 173 gpm.

- An estimate of the vinyl chloride impacted groundwater flow rate into the pond was made based on Darcy's law, where Q=Hydraulic conductivity x hydraulic gradient x discharge area.

  - The hydraulic conductivity near the Pond is assumed to be 280 feet/day, based on results of a Northern Area pumping test.

  - The hydraulic gradient just south of the pond is estimated to be 0.013 foot/foot, based on estimates of the monthly hydrographs provided in the RI Report-Part 1.

  - The discharge area is the cross-sectional area over which groundwater discharges into the Pond (i.e., the plume width x pond water depth). At the downgradient of the plume, the plume width is estimated to be 450 feet. The pond depth is assumed to be 4 feet based on depth measurements taken from the center of the Pond.

  - Based on these inputs, the flow rate of vinyl chloride impacted groundwater into the Pond is estimated to be 34 gpm.

- Based on Appendix M of the RI Report-Part 2, the volume of water in the pond is estimated to be a constant 30,000,000 gallons.

- Attenuation that occurs between the POC wells and the Pond is conservatively neglected.

ACLs were developed based on two sets of conditions: a "low flow" condition and an "average-flow" condition. The low flow condition is intended to represent a reasonable worst case condition, whereby the concentration of groundwater being discharged to the Pond does not exceed surface water quality criteria. ACLs based on reasonable worst case condition would also be protective of other conditions. EPA's default chronic design low flow is defined as the value below which the 4-day harmonic mean flow does not drop more than once every three years on average. However, because very little historical data on Pond conditions is available, it is not possible to determine the low flow condition in this manner. An alternative set of assumptions was therefore used to develop the low flow conditions.

- Influent from the Ogden River is assumed to be negligible.

- The total amount of groundwater flux into the Pond remains constant (i.e., discharge rates of impacted groundwater do not decrease).

- A sensitivity analysis on model parameters, including Pond attenuation rates, was performed to demonstrate that the ACL based on the low flow condition is conservative.

- For vinyl chloride, pond attenuation is neglected. Bioattenuation and volatilization factors are included in developing ACLs for benzene and ethylbenzene. Bioattenuation rates are also included in developing ACLs for toluene and the PAHs. The bioattenuation rates are based on literature values reported in Howard et al (1991). Volatilization rates are based on the calculations performed in Tables 9-11.

The average flow condition is intended to represent conditions that typically represent the Pond system. The purpose of this analysis is to determine the groundwater concentration at which plume concentrations are above analytical detection limits (i.e., concentrations are detectable). Specific assumptions made about the average flow condition are the following.

- The Ogden River influent is assumed to be 100 gpm, based on estimates presented in Appendix N of RI Report-Part 2.
- The total amount of groundwater flux into the Pond is assumed to be constant.
- Bioattenuation and volatilization factors for benzene, ethylbenzene, and vinyl chloride are included in developing ACLs. Bioattenuation rates are also included in developing ACLs for toluene and the PAHs.

Results and Discussion

Low Flow Condition Using Water Quality Criteria-Vinyl Chloride

A base case condition was developed to compare the effect of model parameters input on allowable groundwater concentration developed for vinyl chloride (Table 4). The base case condition makes the assumption that no attenuation of vinyl chloride occurs in the Pond. The base case condition indicates that vinyl chloride concentrations in groundwater at the POC could reach nearly 9.6 mg/L and surface water standards would not be exceeded. The base case concentration is conservative because:

- If Ogden River is allowed into the Pond at a rate of 100 gpm, allowing more dilution to take place, calculations indicate groundwater concentrations could reach 11 mg/L and surface water criteria would not be exceeded.
- Vinyl chloride attenuation via biodegradation and volatilization is likely a very significant attenuation process that is neglected. Assuming a aerobic biodegradation half-life of 28 days (based on the Laboratory Microcosm Test Report), the allowable groundwater concentration is approximately 18 mg/L.
- Decreasing the total flux of groundwater into the Pond by half, but assuming the relative proportion of impacted and non-impacted groundwater remains the same, does not result in a change from the base-case results.
- All attenuation that occurs between the POC and the Pond is neglected.

The highest measured concentration of vinyl chloride at the rail yard at any time is 3.1 mg/L. The model estimates are all well above this level. Based on this comparison, the probability that vinyl chloride concentrations in the Pond would be above surface water quality standards is small, even if the areas of the plume with highest concentrations migrated to the Pond.

Low Flow Condition Using Water Quality Criteria-DNAPL Constituents

A base-case condition was also developed to compare the effect of model parameter input on the allowable groundwater concentration developed for the DNAPL constituents (Table 5). This base case condition makes the assumption that natural attenuation of these compounds occurs at the low end of the range of literature biodegradation rates reported in Howard et al (1991). The allowable concentrations that result from this base case condition are shown below.

Constituent	Allowable Concentration (ug/L)
Benzene	452
Ethylbenzene	348,071
Toluene	1,475,595
Acenapthene	4,358
Anthracene	150,611
Benzo(b)fluoranthene	0.067
Benzo(k)fluoranthene	0.065
Benzo(a)anthracene	0.067
Benzo(a)pyrene	0.067
Chrysene	0.080
Dibenzo(a,h)anthracene	0.066
Fluoranthene	528
Fluorene	26,368
Indeno(1,2,3-cd)pyrene	0.067
Pyrene	14,511

The base case condition results in a conservative estimate of allowable groundwater concentrations because;

- Neglecting Ogden River influent results in a lower allowable groundwater concentration.

- Decreasing the total flux of groundwater into the Pond, assuming the volume of water in the Pond remains the same, increases the Pond retention time. The increased retention time in the Pond allows biological processes to degrade more of the contaminant.

- The bioattenuation rates that were used to develop the base case groundwater concentrations represent the low end of rates reported by Howard et al (1991). With higher attenuation rates in the Pond, a higher concentration of constituents in groundwater can be discharged to the Pond.

- All attenuation that occurs between the POC and the Pond is neglected.

Average Flow Condition and Detectable Levels-Vinyl Chloride

The base case for this average flow condition assumes that the analytical detection limit for vinyl chloride is 2 ug/L, and the inherent variation in sampling results is assumed to be 10 percent of the detection limit. The allowable groundwater concentrations developed with this set of parameters calculate the average concentration of vinyl chloride entering the pond for which Pond levels remain below 2.2 ug/L (Table 6). The calculated allowable concentration for this condition is 62 ug/L. A sensitivity analysis indicates that if influent river water is neglected, the calculated level is 57 ug/L. Decreasing the flux of groundwater into the Pond by half while keeping the Pond volume constant results in an allowable groundwater concentration of 101 ug/L.

Average Flow Condition and Detectable Levels-DNAPL Constituents

The base case for this average flow condition assumes that the analytical detection limit for benzene and ethylbenzene to be 1 ug/L, and the detection limit for the carcinogenic PAHs to be 2 ug/L. The inherent variation in sampling results is assumed to be 10 percent of the detection limit. The base case makes the assumption that natural attenuation of these compounds occurs at the high end of literature biodegradation rates reported in Howard et al. The results of these calculations are shown in Table 7. The allowable concentrations calculated from this base case are shown below.

Constituent	Groundwater Concentration (ug/L)
Benzene	21
Ethylbenzene	34
Toluene	26
Acenapthene	21
Anthracene	10
Benzo(b)fluoranthene	6.5
Benzo(k)fluoranthene	6.2

Benzo(a)anthracene	7.8
Benzo(a)pyrene	9.2
Chrysene	6.5
Dibenzo(a,h)anthracene	6.5
Fluoranthene	7.3
Fluorene	12
Indeno(1,2,3-cd)pyrene	9.1
Pyrene	6.4

The sensitivity of these results to neglecting flow into the Pond from the Ogden River is very small. Decreasing the flux of groundwater into the Pond by half results in calculated groundwater concentrations that are above those calculated in the base case.

Preliminary ACL Determination

Recommended ACLs for the site are shown in Table 8 and discussed below.

- The recommended ACL for vinyl chloride is 9,556 ug/L. However, if concentrations at the POC ever reach 57 ug/L (the surface water criterion), then Pond sampling would also be used to demonstrate compliance with surface water criteria.
- The recommended ACLs for DNAPL constituents are based on low flow conditions and protective of typical flow conditions. If the average COC concentration at the POC is calculated to be at or above the surface water criteria, then Pond water sampling would also be used to demonstrate compliance with surface water quality criteria.

References

Howard et al, *Handbook of Environmental Degradation Rates*, 1991.

USEPA, *Alternate Concentration Limit Guidance Part 1*, OSWER Directive 9481.00-6C, EPA/530-SW-87-017, July 1987.

Table 1
Maximum Detected Concentration of COCs
at the 21st Street Pond, 35-MW1, and 33-MW6/6FP

Parameter Name	Units	21st Street Pond	35-MW1	33-MW6	33-MW6FP
Vinyl Chloride	ug/L	<1	2	<2	<2
Benzene	ug/L	<1	<1	130	35
Ethylbenzene	ug/L	<2	<1	400	120
Toluene	ug/L	<1	<1	15	3
Xylenes (total)	ug/L	<3	<3	180	34
Acenapthene	ug/L	<2	4	220	130
Anthracene	ug/L	<2	<2	18	20
Benzo(b)fluoranthene	ug/L	<2	<2	<2	0.2J
Benzo(k)fluoranthene	ug/L	<2	<2	<2	0.2J
Benzo(a)anthracene	ug/L	<2	<2	0.3J	0.8J
Benzo(a)pyrene	ug/L	<3	<1	<2	0.5J
Chrysene	ug/L	<2	<1	10	0.9J
Dibenzo(a,h)anthracene	ug/L	<1	<2	<2	0.2J
Fluoranthene	ug/L	<2	<2	4	9
Fluorene	ug/L	<2	4	64	52
Indeno(1,2,3-cd)pyrene	ug/L	<2	<2	<2	0.07J
Pyrene	ug/L	<2	0.2	10	14

Table 2

Surface Water Quality Criteria and Analytical Detection Limits

Chemical	Utah Surface Water Quality Criteria[a]			EPA Recommended Criteria[b], Organism (ug/L)	Criteria Applied in Developing ACL (ug/L)
	Class 2B Criteria (ug/L)	Class 3A Criteria (ug/L)	Class 4 Criteria (ug/L)		
CVOCs					
Vinyl Chloride	None	530	None	530	530
DNAPL Constituents					
Benzene	None	51	None	51	51
Ethylbenzene	None	29,000	None	29,000	29,000
Toluene	None	200,000	None	200,000	200,000
Xylenes (total)	None	None	None	None	None
Acenapthene	None	990	None	990	990
Anthracene	None	40,000	None	40,000	40,000
Benzo(b)fluoranthene	None	0.018	None	0.018	0.018
Benzo(k)fluoranthene	None	0.018	None	0.018	0.018
Benzo(a)anthracene	None	0.018	None	0.018	0.018
Benzo(a)pyrene	None	0.018	None	0.018	0.018
Chrysene	None	0.018	None	0.018	0.018
Dibenzo(a,h)anthracene	None	0.018	None	0.018	0.018
Fluoranthene	None	140	None	140	140
Fluorene	None	5,300	None	5,300	5,300
Ideno(1,2,3-cd)pyrene	None	0.018	None	0.018	0.018
Pyrene	None	4,000	None	4,000	4,000

a Utah Water Quality Criteria, UAC R317-2, Effective 3/1/04

b National Recommended Water Quality Criteria:2002, EPA-822-R-02-047, USEPA, November 2002

Table 3
Mathematical Model Used to Develop Groundwater ACLs

$$ACL = \frac{\left(Q_{R,Out} \times C_{R,Out} + k_{Pond} \times V_{Pond} \times C_{Pond}\right) - \left(Q_{GW,Other} \times C_{GW,Other} + Q_{R,In} \times C_{R,In}\right)}{Q_{GW,CVOC}}$$

ACL	Allowable groundwater concentration of CVOC entering the Pond (to be determined, ug/L)
$Q_{R,Out}$	Effluent flowrate out of the Pond, into Ogden River (gpm)
$C_{R,Out}$	Concentration of CVOC in Pond effluent. Assumes C_{pond}=$C_{R,Out}$ (as determined to be allowable, ug/L)
$t_{1/2,\,bio}$	Bioattenuation half-life (days)
$t_{1/2,\,vol}$	Volatilization half-life (days), see Table 8
k_{Pond}	Pond Attenuation Rate (1/min)
V_{Pond}	Pond Volume (gallons)
C_{Pond}	Concentration of CVOC in the Pond (as allowable, ug/L)
$Q_{GW,Other}$	Flowrate of other groundwater into the Pond (gpm)
$C_{GW,Other}$	Concentration of CVOC in other groundwater entering the Pond (Assumed to be 0, ug/L)
$Q_{R,I}$	Ogden River influent flowrate (gpm)
$C_{R,In}$	Concentration of CVOC in Ogden River influent (Assumed to be 0, ug/L)
$Q_{GW,CVOC}$	Flowrate of CVOC plume groundwater into the Pond (gpm)

Table 4

Northern Plume ACL Model Results: Low Flow Condition

Parameter	Influent River Water		Influent Groundwater			Attenuation					Effluent Pond Water		Groundwater Concentration
	$Q_{R,I}$	$C_{R,In}$	$Q_{GW,CVOC}$	$Q_{GW,Other}$	$C_{GW,Other}$	V_{Pond}	$t_{1/2,\ bio}$	$t_{1/2,\ vol}$	k_{Pond}	C_{Pond}	$Q_{R,Out}$	$C_{R,Out}$	
	(gpm)	(ug/L)	(gpm)	(gpm)	(ug/L)	(gal)	(days)	(days)	(1/min)	(ug/L)	(gpm)	(ug/L)	(ug/L)
Low Flow Condition-Base Case													
Vinyl Chloride	0	0.5	34	586	1	30,000,000	None	None	None	530	620	530	9,647
Effect of Influent River Water													
Vinyl Chloride	100	0.5	34	586	1	30,000,000	None	None	None	530	720	530	11,205
Low Flow Condition-Assuming total groundwater flux to pond decreases by half.													
Vinyl Chloride	0	0.5	17	293	1	30,000,000	None	None	None	530	310	530	9,647
Low Flow Condition-Including Bioattenuation													
Vinyl Chloride	0	0.5	34	586	1	30,000,000	28	1,168	1.76E-05	530	620	530	17,880

Notes:

$$ACL = \frac{\left(Q_{R,Out} \times C_{R,Out} + k_{Pond} \times V_{Pond} \times C_{Pond}\right) - \left(Q_{GW,Other} \times C_{GW,Other} + Q_{R,In} \times C_{R,In}\right)}{Q_{GW,CVOC}}$$

ACL Allowable groundwater concentration of CVOC entering the Pond (to be determined, ug/L)
$Q_{R,Out}$ Effluent flowrate out of the Pond, into Ogden River (gpm)
$C_{R,Out}$ Concentration of CVOC in Pond effluent. Assumes $C_{pond}=C_{R,Out}$ (as determined to be allowable, ug/L)
$t_{1/2,\ bio}$ Bioattenuation half-life (days)
$t_{1/2,\ vol}$ Volatilization half-life (days), see Table 8
k_{Pond} Pond Attenuation Rate (1/min)
V_{Pond} Pond Volume (gallons)
C_{Pond} Concentration of CVOC in the Pond (as allowable, ug/L)
$Q_{GW,Other}$ Flowrate of other groundwater into the Pond (gpm)
$C_{GW,Other}$ Concentration of CVOC in other groundwater entering the Pond (Assumed to be 0, ug/L)
$Q_{R,I}$ Ogden River influent flowrate (gpm)
$C_{R,In}$ Concentration of CVOC in Ogden River influent (Assumed to be 0, ug/L)
$Q_{GW,CVOC}$ Flowrate of CVOC plume groundwater into the Pond (gpm)

Biological degradation rates taken from Handbook of Environmental Degradation Rates, Howard et al., 1991

Table 5
DNAPL Zone ACL Model Results: Low Flow Condition

DNAPL Zone ACL Model: Low Flow Condition Results

	Influent River Water		Influent Groundwater			Attenuation					Effluent Pond Water		Groundwater Concentration
Parameter	$Q_{R,I}$	$C_{R,In}$	$Q_{GW,COC}$	$Q_{GW,Other}$	$C_{GW,Other}$	V_{Pond}	$t_{1/2,sw}$	$t_{1/2,vol}$	k_{Pond}	C_{Pond}	$Q_{R,Out}$	$C_{R,Out}$	
	(gpm)	(ug/L)	(gpm)	(gpm)	(ug/L)	(gal)	(days)	(days)	(1/min)	(ug/L)	(gpm)	(ug/L)	(ug/L)
Low Flow Condition-Base Case													
Benzene	0	0	173	447	0	30,000,000	16	1,305	3.05E-05	51	620	51	452
Ethylbenzene	0	0	173	447	0	30,000,000	10	1,522	4.85E-05	29,000	620	29,000	348,071
Toluene	0	0	173	447	0	30,000,000	22	--	2.19E-05	200,000	620	200,000	1,475,595
Acenapthene	0	0	173	447	0	30,000,000	102	--	4.72E-06	990	620	990	4,358
Anthracene	0	0	173	447	0	30,000,000	460	--	1.05E-06	40,000	620	40,000	150,611
Benzo(b)fluoranthene	0	0	173	447	0	30,000,000	610	--	7.89E-07	0.018	620	0.018	0.067
Benzo(k)fluoranthene	0	0	173	447	0	30,000,000	2140	--	2.25E-07	0.018	620	0.018	0.065
Benzo(a)anthracene	0	0	173	447	0	30,000,000	680	--	7.08E-07	0.018	620	0.018	0.067
Benzo(a)pyrene	0	0	173	447	0	30,000,000	530	--	9.08E-07	0.018	620	0.018	0.067
Chrysene	0	0	173	447	0	30,000,000	100	--	4.81E-06	0.018	620	0.018	0.080
Dibenzo(a,h)anthracene	0	0	173	447	0	30,000,000	940	--	5.12E-07	0.018	620	0.018	0.066
Fluoranthene	0	0	173	447	0	30,000,000	440	--	1.09E-06	140	620	140	528
Fluorene	0	0	173	447	0	30,000,000	60	--	8.02E-06	5,300	620	5,300	26,368
Ideno(1,2,3-cd)pyrene	0	0	173	447	0	30,000,000	730	--	6.59E-07	0.018	620	0.018	0.067
Pyrene	0	0	173	447	0	30,000,000	1900	--	2.53E-07	4,000	620	4,000	14,511

Table 5

DNAPL Zone ACL Model Results: Low Flow Condition

DNAPL Zone ACL Model: Low Flow Condition Results

Parameter	Influent River Water		Influent Groundwater			Attenuation					Effluent Pond Water		Groundwater Concentration
	$Q_{R,I}$	$C_{R,In}$	$Q_{GW,COC}$	$Q_{GW,Other}$	$C_{GW,Other}$	V_{Pond}	$t_{1/2,sw}$	$t_{1/2,vol}$	k_{Pond}	C_{Pond}	$Q_{R,Out}$	$C_{R,Out}$	
	(gpm)	(ug/L)	(gpm)	(gpm)	(ug/L)	(gal)	(days)	(days)	(1/min)	(ug/L)	(gpm)	(ug/L)	(ug/L)
Effect of Influent River Water													
Benzene	100	0	173	447	0	30,000,000	16	1,305	3.05E-05	51	720	51	482
Ethylbenzene	100	0	173	447	0	30,000,000	10	1,522	4.85E-05	29,000	720	29,000	364,834
Toluene	100	0	173	447	0	30,000,000	22	–	2.19E-05	200,000	720	200,000	1,591,202
Acenapthene	100	0	173	447	0	30,000,000	102	–	4.72E-06	990	720	990	4,930
Anthracene	100	0	173	447	0	30,000,000	460	–	1.05E-06	40,000	720	40,000	173,732
Benzo(b)fluoranthene	100	0	173	447	0	30,000,000	610	–	7.89E-07	0.018	720	0.018	0.077
Benzo(k)fluoranthene	100	0	173	447	0	30,000,000	2140	–	2.25E-07	0.018	720	0.018	0.076
Benzo(a)anthracene	100	0	173	447	0	30,000,000	680	–	7.08E-07	0.018	720	0.018	0.077
Benzo(a)pyrene	100	0	173	447	0	30,000,000	530	–	9.08E-07	0.018	720	0.018	0.078
Chrysene	100	0	173	447	0	30,000,000	100	–	4.81E-06	0.018	720	0.018	0.090
Dibenzo(a,h)anthracene	100	0	173	447	0	30,000,000	940	–	5.12E-07	0.018	720	0.018	0.077
Fluoranthene	100	0	173	447	0	30,000,000	440	–	1.09E-06	140	720	140	609
Fluorene	100	0	173	447	0	30,000,000	60	–	8.02E-06	5,300	720	5,300	29,431
Ideno(1,2,3-cd)pyrene	100	0	173	447	0	30,000,000	730	–	6.59E-07	0.018	720	0.018	0.077
Pyrene	100	0	173	447	0	30,000,000	1900	–	2.53E-07	4,000	720	4,000	16,823
Low Flow Condition-Assuming total groundwater flux to pond decreases by half.													
Benzene	0	0	86.5	223.5	0	30,000,000	16	1,305	3.05E-05	51	310	51	722
Ethylbenzene	0	0	86.5	223.5	0	30,000,000	10	1,522	4.85E-05	29,000	310	29,000	592,212
Toluene	0	0	86.5	223.5	0	30,000,000	22	–	2.19E-05	200,000	310	200,000	2,234,426
Acenapthene	0	0	86.5	223.5	0	30,000,000	102	–	4.72E-06	990	310	990	5,168
Anthracene	0	0	86.5	223.5	0	30,000,000	460	–	1.05E-06	40,000	310	40,000	157,869
Benzo(b)fluoranthene	0	0	86.5	223.5	0	30,000,000	610	–	7.89E-07	0.018	310	0.018	0.069
Benzo(k)fluoranthene	0	0	86.5	223.5	0	30,000,000	2140	–	2.25E-07	0.018	310	0.018	0.066
Benzo(a)anthracene	0	0	86.5	223.5	0	30,000,000	680	–	7.08E-07	0.018	310	0.018	0.069
Benzo(a)pyrene	0	0	86.5	223.5	0	30,000,000	530	–	9.08E-07	0.018	310	0.018	0.070
Chrysene	0	0	86.5	223.5	0	30,000,000	100	–	4.81E-06	0.018	310	0.018	0.095
Dibenzo(a,h)anthracene	0	0	86.5	223.5	0	30,000,000	940	–	5.12E-07	0.018	310	0.018	0.068
Fluoranthene	0	0	86.5	223.5	0	30,000,000	440	–	1.09E-06	140	310	140	555
Fluorene	0	0	86.5	223.5	0	30,000,000	60	–	8.02E-06	5,300	310	5,300	33,741
Ideno(1,2,3-cd)pyrene	0	0	86.5	223.5	0	30,000,000	730	–	6.59E-07	0.018	310	0.018	0.069
Pyrene	0	0	86.5	223.5	0	30,000,000	1900	–	2.53E-07	4,000	310	4,000	14,687

Table 5

DNAPL Zone ACL Model Results: Low Flow Condition

DNAPL Zone ACL Model: Low Flow Condition Results

Parameter	Influent River Water		Influent Groundwater			Attenuation					Effluent Pond Water		Groundwater Concentration
	$Q_{R,I}$	$C_{R,In}$	$Q_{GW,COC}$	$Q_{GW,Other}$	$C_{GW,Other}$	V_{Pond}	$t_{1/2,sw}$	$t_{1/2,vol}$	k_{Pond}	C_{Pond}	$Q_{R,Out}$	$C_{R,Out}$	
	(gpm)	(ug/L)	(gpm)	(gpm)	(ug/L)	(gal)	(days)	(days)	(1/min)	(ug/L)	(gpm)	(ug/L)	(ug/L)
Low-flow Condition-Including Bioattenuation & Photolysis													
Benzene	0	0	173	447	0	30,000,000	16	1,305	3.05E-05	51	620	51	452
Ethylbenzene	0	0	173	447	0	30,000,000	10	1,522	4.85E-05	29,000	620	29,000	348,071
Toluene	0	0	173	447	0	30,000,000	22	–	2.19E-05	200,000	620	200,000	1,475,595
Acenapthene	0	0	173	447	0	30,000,000	12.5	–	3.85E-05	990	620	990	10,159
Anthracene	0	0	173	447	0	30,000,000	0.071	–	6.80E-03	40,000	620	40,000	47,280,189
Benzo(b)fluoranthene	0	0	173	447	0	30,000,000	30	–	1.60E-05	0.018	620	0.018	0.115
Benzo(k)fluoranthene	0	0	173	447	0	30,000,000	21	–	2.32E-05	0.018	620	0.018	0.137
Benzo(a)anthracene	0	0	173	447	0	30,000,000	0.125	–	3.85E-03	0.018	620	0.018	12.084
Benzo(a)pyrene	0	0	173	447	0	30,000,000	0.046	–	1.05E-02	0.018	620	0.018	32.846
Chrysene	0	0	173	447	0	30,000,000	0.542	–	8.89E-04	0.018	620	0.018	2.838
Dibenzo(a,h)anthracene	0	0	173	447	0	30,000,000	33	–	1.48E-05	0.018	620	0.018	0.111
Fluoranthene	0	0	173	447	0	30,000,000	2.6	–	1.85E-04	140	620	140	4,996
Fluorene	0	0	173	447	0	30,000,000	60	–	8.02E-06	5,300	620	5,300	26,368
Ideno(1,2,3-cd)pyrene	0	0	173	447	0	30,000,000	250	–	1.93E-06	0.018	620	0.018	0.071
Pyrene	0	0	173	447	0	30,000,000	0.085	–	5.66E-03	4,000	620	4,000	3,942,405

Notes:

$$ACL = \frac{(Q_{R,Out} \times C_{R,Out} + k_{Pond} \times V_{Pond} \times C_{Pond}) - (Q_{GW,Other} \times C_{GW,Other} + Q_{R,In} \times C_{R,In})}{Q_{GW,CVOC}}$$

ACL Allowable groundwater concentration of CVOC entering the Pond (to be determined, ug/L)

$Q_{R,Out}$ Effluent flowrate out of the Pond, into Ogden River (gpm)

$C_{R,Out}$ Concentration of CVOC in Pond effluent. Assumes C_{pond}=$C_{R,Out}$ (as determined to be allowable, ug/L)

k_{Pond} Pond Attenuation Rate (1/min)

V_{Pond} Pond Volume (gallons)

C_{Pond} Concentration of COC in the Pond (as allowable, ug/L)

$Q_{GW,Other}$ Flowrate of other groundwater into the Pond (gpm)

$C_{GW,Other}$ Concentration of COC in other groundwater entering the Pond (Assumed to be 0, ug/L)

$Q_{R,I}$ Ogden River influent flowrate (gpm)

$C_{R,In}$ Concentration of COC in Ogden River influent (Assumed to be 0, ug/L)

$Q_{GW,cvoc}$ Flowrate of COC plume groundwater into the Pond (gpm)

Degradation rates taken from Handbook of Environmental Degradation Rates, Howard et al., 1991.
Base case rates are based on the low-end of biodegration rates reported.
Case 3 rates are based on the low-end of surface water degratdation rates reported.
Peach shaded cells represent concentrations above solubility values reported by Suthersan (1997).

Table 6

Northern Plume ACL Model Results: Average Flow Condition

Northern Plume ACL Model: Average Flow Condition Results

Parameter	Influent River Water		Influent Groundwater			Attenuation					Effluent Pond Water		Groundwater Concentration
	$Q_{R,I}$	$C_{R,In}$	$Q_{GW,CVOC}$	$Q_{GW,Other}$	$C_{GW,Other}$	V_{Pond}	$t_{1/2,\ bio}$	$t_{1/2,\ vol}$	k_{Pond}	C_{Pond}	$Q_{R,Out}$	$C_{R,Out}$	
	(gpm)	(ug/L)	(gpm)	(gpm)	(ug/L)	(gal)	(days)	(days)	(1/min)	(ug/L)	(gpm)	(ug/L)	(ug/L)
Avg. Flow Condition-Base Case													
Vinyl Chloride	100	0.5	34	586	1	30,000,000	28	1,168	1.76E-05	2.2	720	2.2	62
Effect of Influent River Water													
Vinyl Chloride	0	0.5	34	586	1	30,000,000	28	1,168	1.76E-05	2.2	620	2.2	57
Avg. Flow Condition-Assuming total groundwater flux to pond decreases by half.													
Vinyl Chloride	100	0.5	17	293	1	30,000,000	28	1,168	1.76E-05	2.2	410	2.2	101

Notes:

$$ACL = \frac{(Q_{R,Out} \times C_{R,Out} + k_{Pond} \times V_{Pond} \times C_{Pond}) - (Q_{GW,Other} \times C_{GW,Other} + Q_{R,In} \times C_{R,In})}{Q_{GW,CVOC}}$$

- ACL Allowable groundwater concentration of CVOC entering the Pond (to be determined, ug/L)
- $Q_{R,Out}$ Effluent flowrate out of the Pond, into Ogden River (gpm)
- $C_{R,Out}$ Concentration of CVOC in Pond effluent. Assumes $C_{pond}=C_{R,Out}$ (as determined to be allowable, ug/L)
- $t_{1/2,\ bio}$ Bioattenuation half-life (days)
- $t_{1/2,\ vol}$ Volatilization half-life (days), see Table 8
- k_{Pond} Pond Attenuation Rate (1/min)
- V_{Pond} Pond Volume (gallons)
- C_{Pond} Concentration of CVOC in the Pond (as allowable, ug/L)
- $Q_{GW,Other}$ Flowrate of other groundwater into the Pond (gpm)
- $C_{GW,Other}$ Concentration of CVOC in other groundwater entering the Pond (Assumed to be 0, ug/L)
- $Q_{R,I}$ Ogden River influent flowrate (gpm)
- $C_{R,In}$ Concentration of CVOC in Ogden River influent (Assumed to be 0, ug/L)
- $Q_{GW,CVOC}$ Flowrate of CVOC plume groundwater into the Pond (gpm)

Biological degradation rates taken from Handbook of Environmental Degradation Rates, Howard et al., 1991

Table 7
DNAPL Zone ACL Model Results: Average Flow Conditions

DNAPL Zone Groundwater ACL Model: Average Flow Condition Results

	Influent River Water		Influent Groundwater			Attenuation					Effluent Pond Water		Groundwater
Parameter	$Q_{R,I}$	$C_{R,In}$	$Q_{GW,COC}$	$Q_{GW,Other}$	$C_{GW,Other}$	V_{Pond}	$t_{1/2,bio}$	$t_{1/2,vol}$	k_{Pond}	C_{Pond}	$Q_{R,Out}$	$C_{R,Out}$	Concentration
	(gpm)	(ug/L)	(gpm)	(gpm)	(ug/L)	(gal)	(days)	(days)	(1/min)	(ug/L)	(gpm)	(ug/L)	(ug/L)
Avg. Flow Condition-Base Case													
Benzene	100	0.5	173	447	0.5	30,000,000	5	1,305	9.67E-05	1.1	720	1.1	21
Ethylbenzene	100	0.5	173	447	0.5	30,000,000	3	1,522	1.61E-04	1.1	720	1.1	34
Toluene	100	0.5	173	447	0.5	30,000,000	4	--	1.20E-04	1.1	720	1.1	26
Acenapthene	100	1	173	447	1	30,000,000	12.3	--	3.91E-05	2.2	720	2.2	21
Anthracene	100	1	173	447	1	30,000,000	50	--	9.63E-06	2.2	720	2.2	10
Benzo(b)fluoranthene	100	1	173	447	1	30,000,000	360	--	1.34E-06	2.2	720	2.2	6.5
Benzo(k)fluoranthene	100	1	173	447	1	30,000,000	910	--	5.29E-07	2.2	720	2.2	6.2
Benzo(a)anthracene	100	1	173	447	1	30,000,000	102	--	4.72E-06	2.2	720	2.2	7.8
Benzo(a)pyrene	100	1	173	447	1	30,000,000	57	--	8.44E-06	2.2	720	2.2	9.2
Chrysene	100	1	173	447	1	30,000,000	371	--	1.30E-06	2.2	720	2.2	6.5
Dibenzo(a,h)anthracene	100	1	173	447	1	30,000,000	361	--	1.33E-06	2.2	720	2.2	6.5
Fluoranthene	100	1	173	447	1	30,000,000	140	--	3.44E-06	2.2	720	2.2	7.3
Fluorene	100	1	173	447	1	30,000,000	32	--	1.50E-05	2.2	720	2.2	12
Ideno(1,2,3-cd)pyrene	100	1	173	447	1	30,000,000	60	--	8.02E-06	2.2	720	2.2	9.1
Pyrene	100	1	173	447	1	30,000,000	506	--	9.51E-07	2.2	720	2.2	6.4
Effect of Influent River Water													
Benzene	0	0.5	173	447	0.5	30,000,000	5	1,305	9.67E-05	1.1	620	1.1	21
Ethylbenzene	0	0.5	173	447	0.5	30,000,000	3	1,522	1.61E-04	1.1	620	1.1	33
Toluene	0	0.5	173	447	0.5	30,000,000	4	--	1.20E-04	1.1	620	1.1	26
Acenapthene	0	1	173	447	1	30,000,000	12.3	--	3.91E-05	2.2	620	2.2	20
Anthracene	0	1	173	447	1	30,000,000	50	--	9.63E-06	2.2	620	2.2	9.0
Benzo(b)fluoranthene	0	1	173	447	1	30,000,000	360	--	1.34E-06	2.2	620	2.2	5.8
Benzo(k)fluoranthene	0	1	173	447	1	30,000,000	910	--	5.29E-07	2.2	620	2.2	5.5
Benzo(a)anthracene	0	1	173	447	1	30,000,000	102	--	4.72E-06	2.2	620	2.2	7.1
Benzo(a)pyrene	0	1	173	447	1	30,000,000	57	--	8.44E-06	2.2	620	2.2	8.5
Chrysene	0	1	173	447	1	30,000,000	371	--	1.30E-06	2.2	620	2.2	5.8
Dibenzo(a,h)anthracene	0	1	173	447	1	30,000,000	361	--	1.33E-06	2.2	620	2.2	5.8
Fluoranthene	0	1	173	447	1	30,000,000	140	--	3.44E-06	2.2	620	2.2	6.6
Fluorene	0	1	173	447	1	30,000,000	32	--	1.50E-05	2.2	620	2.2	11
Ideno(1,2,3-cd)pyrene	0	1	173	447	1	30,000,000	60	--	8.02E-06	2.2	620	2.2	8.4
Pyrene	0	1	173	447	1		506	--	9.51E-07				

Table 7
DNAPL Zone ACL Model Results: Average Flow Conditions

Avg. Flow Condition-Assuming total groundwater flux to pond decreases by half.													
Benzene	100	0.5	86.5	223.5	0.5	30,000,000	5	1,305	9.67E-05	1.1	410	1.1	40
Ethylbenzene	100	0.5	86.5	223.5	0.5	30,000,000	3	1,522	1.61E-04	1.1	410	1.1	65
Toluene	100	0.5	86.5	223.5	0.5	30,000,000	4	--	1.20E-04	1.1	410	1.1	49
Acenapthene	100	1	86.5	223.5	1	30,000,000	12.3	--	3.91E-05	2.2	410	2.2	37
Anthracene	100	1	86.5	223.5	1	30,000,000	50	--	9.63E-06	2.2	410	2.2	14
Benzo(b)fluoranthene	100	1	86.5	223.5	1	30,000,000	360	--	1.34E-06	2.2	410	2.2	7.7
Benzo(k)fluoranthene	100	1	86.5	223.5	1	30,000,000	910	--	5.29E-07	2.2	410	2.2	7.1
Benzo(a)anthracene	100	1	86.5	223.5	1	30,000,000	102	--	4.72E-06	2.2	410	2.2	10
Benzo(a)pyrene	100	1	86.5	223.5	1	30,000,000	57	--	8.44E-06	2.2	410	2.2	13
Chrysene	100	1	86.5	223.5	1	30,000,000	371	--	1.30E-06	2.2	410	2.2	7.7
Dibenzo(a,h)anthracene	100	1	86.5	223.5	1	30,000,000	361	--	1.33E-06	2.2	410	2.2	7.7
Fluoranthene	100	1	86.5	223.5	1	30,000,000	140	--	3.44E-06	2.2	410	2.2	9.3
Fluorene	100	1	86.5	223.5	1	30,000,000	32	--	1.50E-05	2.2	410	2.2	18
Ideno(1,2,3-cd)pyrene	100	1	86.5	223.5	1	30,000,000	60	--	8.02E-06	2.2	410	2.2	13
Pyrene	100	1	86.5	223.5	1	30,000,000	506	--	9.51E-07	2.2	410	2.2	7.4

Notes:

$$ACL = \frac{\left(Q_{R,Out} \times C_{R,Out} + k_{Pond} \times V_{Pond} \times C_{Pond}\right) - \left(Q_{GW,Other} \times C_{GW,Other} + Q_{R,In} \times C_{R,In}\right)}{Q_{GW,CVOC}}$$

ACL Allowable groundwater concentration of CVOC entering the Pond (to be determined, ug/L)
$Q_{R,Out}$ Effluent flowrate out of the Pond, into Ogden River (gpm)
$C_{R,Out}$ Concentration of CVOC in Pond effluent. Assumes C_{pond}=$C_{R,Out}$ (as determined to be allowable, ug/L)
$t_{1/2,\,bio}$ Bioattenuation half-life (days)
$t_{1/2,\,vol}$ Volatilization half-life (days), See Tables 9 and 10
k_{Pond} Pond Attenuation Rate (1/min)
V_{Pond} Pond Volume (gallons)
C_{Pond} Concentration of CVOC in the Pond (as allowable, ug/L)
$Q_{GW,Other}$ Flowrate of other groundwater into the Pond (gpm)
$C_{GW,Other}$ Concentration of CVOC in other groundwater entering the Pond (Assumed to be 0, ug/L)
$Q_{R,I}$ Ogden River influent flowrate (gpm)
$C_{R,In}$ Concentration of CVOC in Ogden River influent (Assumed to be 0, ug/L)
$Q_{GW,CVOC}$ Flowrate of CVOC plume groundwater into the Pond (gpm)

Biological degradation rates taken from Handbook of Environmental Degradation Rates, Howard et al., 1991

Table 8
Recommended ACLs

Chemical	Recommended ACL (ug/L)
CVOCs	
Vinyl Chloride	9,556
DNAPL Constituents	
Benzene	452
Ethylbenzene	348,071
Toluene	1,475,595
Acenapthene	4,358
Anthracene	150,611
Benzo(b)fluoranthene	0.067
Benzo(k)fluoranthene	0.065
Benzo(a)anthracene	0.067
Benzo(a)pyrene	0.067
Chrysene	0.080
Dibenzo(a,h)anthracene	0.066
Fluoranthene	528
Fluorene	26,368
Ideno(1,2,3-cd)pyrene	0.067
Pyrene	14,511

Table 9
Volatilization Rate Calculations-Vinyl Chloride

Attenuation Rate Calculations

$$k_v = \frac{1}{L}\left[\frac{1}{k_l} + \frac{RT}{H_c k_g}\right]^{-1}$$

From Moore and Ramamoorthy, Organic Chemicals in Natural Waters, 1984

Factor (units)	Symbol	Value
Volatilization rate constant (min^{-1})	k_v	4.12E-07
Volatilzation half-life (days)	$t_{v,1/2}$	1,168
Volatilization rate constant (hr^{-1})	k_v	2.47E-05
Depth (cm)	L	121.92
Mass transfer coefficient in the liquid phase (cm/hr)	k_l	0.003015814
Henry's law constant (torr/M)	H_c	2.11E+06
Mass transfer coefficient in the gas phase (cm/hr)	k_g	1.073278283
Gas constant (liter-atm-mole^{-1}-degree^{-1})	R	0.082056
Absolute Temperature (degrees Kelvin)	T	298

Conversion Factors

Depth (feet)	4
Depth (cm)	121.92

Henry's Constant (atm-m^3/mol)	2.78	for VC
Henry's Constant (torr/M)	2.11E+06	

Temperature (deg C)	25
Temperature (deg K)	298

Related Equations (From Schwazenbach et. al, Environmental Organic Chemistry)

Liquid phase transfer coefficient (cm/hr)	0.003016		k_l=D/d
Diffusion coefficient (D), liquid (cm^2/s)	1.51E-05	for VC	$D=D_{known} \times (MW_{known}/MW_{unknown})^{0.5}$
Boundary layer thickness (d), liquid (cm)	0.005	for VC	Schwazenbach et. al provides values of 5E-3 to 5E-2 cm
Diffusion coefficient, liquid (cm^2/s)	1.04E-05	for TCE	reported at 1 atm, 25 deg C
Molecular weight	131.39	for TCE	
Molecular weight	62.5	for VC	

Air phase transfer coefficient (cm/hr)	1.073278		k_l=D/d
Diffusion coefficient (D), air (cm^2/s)	0.107328	for VC	$D=D_{known} \times (MW_{known}/MW_{unknown})^{0.5}$
Boundary layer thickness (d), air (cm)	0.1	for VC	Schwazenbach et. al provides values of 1 to 0.1 cm
Diffusion coefficient, air (cm^2/s)	0.096	for benzene	reported at 1 atm, 25 deg C
Molecular weight	78.12	for benzene	
Molecular weight	62.5	for VC	

Table 10
Benzene Volatilization Rate Calculations

Attenuation Rate Calculations

$$k_v = \frac{1}{L}\left[\frac{1}{kl} + \frac{RT}{H_c k_g}\right]^{-1}$$

From Moore and Ramamoorthy, Organic Chemicals in Natural Waters, 1984

Factor (units)	Symbol	Value
Volatilization rate constant (min^{-1})	k_v	3.69E-07
Volatilzation half-life (days)	$t_{v,1/2}$	1,305
Volatilization rate constant (hr^{-1})	k_v	2.21E-05
Depth (cm)	L	121.92
Mass transfer coefficient in the liquid phase (cm/hr)	k_l	0.002697512
Henry's law constant (torr/M)	H_c	4.16E+03
Mass transfer coefficient in the gas phase (cm/hr)	k_g	0.96
Gas constant (liter-atm-mole^{-1}-degree^{-1})	R	0.082056
Absolute Temperature (degrees Kelvin)	T	298

Conversion Factors

Depth (feet)	4
Depth (cm)	121.92

Henry's Constant (atm-m^3/mol)	0.00548	for benzene
Henry's Constant (torr/M)	4.16E+03	

Temperature (deg C)	25
Temperature (deg K)	298

Related Equations (From Schwazenbach et. al, Environmental Organic Chemistry)

Liquid phase transfer coefficient (cm/hr)	0.002698		k_l=D/d
Diffusion coefficient (D), liquid (cm^2/s)	1.35E-05	for benzene	$D=D_{known} \times (MW_{known}/MW_{unknown})^{0.5}$
Boundary layer thickness (d), liquid (cm)	0.005	for benzene	Schwazenbach et. al provides values of 5E-3 to 5E-2 cm
Diffusion coefficient, liquid (cm^2/s)	1.04E-05	for TCE	reported at 1 atm, 25 deg C
Molecular weight	131.39	for TCE	
Molecular weight	78.12	for benzene	

Air phase transfer coefficient (cm/hr)	0.96		k_l=D/d
Diffusion coefficient (D), air (cm^2/s)	0.096	for benzene	reported at 1 atm, 25 deg C
Boundary layer thickness (d), air (cm)	0.1	for benzene	Schwazenbach et. al provides values of 1 to 0.1 cm

Table 11
Ethylbenzene Volatilization Rate Calculations

Attenuation Rate Calculations

$$k_v = \frac{1}{L}\left[\frac{1}{kl} + \frac{RT}{H_c k_g}\right]^{-1}$$

From Moore and Ramamoorthy, Organic Chemicals in Natural Waters, 1984

Factor (units)	Symbol	Value
Volatilization rate constant (min^{-1})	k_v	3.16E-07
Volatilzation half-life (days)	$t_{v,1/2}$	1,522
Volatilization rate constant (hr^{-1})	k_v	1.90E-05
Depth (cm)	L	121.92
Mass transfer coefficient in the liquid phase (cm/hr)	k_l	0.002313895
Henry's law constant (torr/M)	H_c	6.60E+03
Mass transfer coefficient in the gas phase (cm/hr)	k_g	0.823476939
Gas constant (liter-atm-mole^{-1}-degree^{-1})	R	0.082056
Absolute Temperature (degrees Kelvin)	T	298

Conversion Factors

Depth (feet)	4
Depth (cm)	121.92

Henry's Constant (atm-m^3/mol)	0.00868	for ethylbenzene
Henry's Constant (torr/M)	6.60E+03	

Temperature (deg C)	25
Temperature (deg K)	298

Related Equations (From Schwazenbach et. al, Environmental Organic Chemistry)

Liquid phase transfer coefficient (cm/hr)	0.002314		k_l=D/d
Diffusion coefficient (D), liquid (cm^2/s)	1.16E-05	for ethylbenzene	$D=D_{known} \times (MW_{known}/MW_{unknown})^{0.5}$
Boundary layer thickness (d), liquid (cm)	0.005	for ethylbenzene	Schwazenbach et. al provides values of 5E-3 to 5E-2 cm
Diffusion coefficient, liquid (cm^2/s)	1.04E-05	for TCE	reported at 1 atm, 25 deg C
Molecular weight	131.39	for TCE	
Molecular weight	106.17	for ethylbenzene	

Air phase transfer coefficient (cm/hr)	0.823477		k_l=D/d
Diffusion coefficient (D), air (cm^2/s)	0.082348	for ethylbenzene	$D=D_{known} \times (MW_{known}/MW_{unknown})^{0.5}$
Boundary layer thickness (d), air (cm)	0.1	for ethylbenzene	Schwazenbach et. al provides values of 1 to 0.1 cm
Diffusion coefficient, air (cm^2/s)	0.096	for benzene	reported at 1 atm, 25 deg C
Molecular weight	78.12	for benzene	
Molecular weight	106.17	for ethylbenzene	

MEMORANDUM

THE FORRESTER GROUP
INSIGHTFUL ENVIRONMENTAL SOLUTIONS℠

Date: December 11, 2003

To: File

From: Bob Kick, P.G.
Jay Hoskins

Subject: UPRR Ogden Rail Yard – Attachment A
Groundwater Flow and Discharge Evaluation

This memo is part of a CERCLA alternative cleanup level ("ACL") demonstration for the UPRR Ogden, Utah rail yard. The purpose of this discussion is to evaluate the basis for establishing the potential ultimate discharge of impacted groundwater to surface water from three Areas of Interest ("AOIs"). The three groundwater plumes include:

- A vinyl chloride plume extending approximately from AOI-21 to AOI-26 and referred to as the "Southern Plume" (Area 2);
- A vinyl chloride plume extending approximately from AOI-38 to AOI-35 and referred to as the "Northern Plume" (Area 1); and
- A PAH / BTEX plume (AOI-33) present above the area of DNAPL occurrence southeast of the 21st Street Pond (Area 1).

CERCLA 121(d) (2) (B) (ii) provides a set of three specific conditions limiting the use of ACLs at Superfund sites where MCLs would otherwise be applicable or relevant and appropriate. The statute prohibits use of any process for establishing ACLs for hazardous constituents in ground water (where there is not a projected entry into surface water) for purposes of an on-site cleanup that assumes a point of human exposure beyond the boundaries of the facility, except where three specific conditions are met:

> *"(1) There are known or projected points of entry of such groundwater into surface water; and*
>
> *(2) on the basis of measurements or projections, there is or will be no statistically significant increase of such constituents from such groundwater in such surface water at the point of entry or at any point where there is reason to believe accumulation of constituents may occur downstream; and*
>
> *(3) the remedial action includes enforceable measures that will preclude human exposure to the contaminated groundwater at any point between the facility boundary and all known and projected points of entry of such groundwater into surface water."*

If the conditions are met, the assumed points of human exposure may be at such known and projected points of entry. This discussion addresses the first of these three requirements.

605 North Boonville Avenue, Springfield, MO 65806, p 417.864.6444, f 417.864.6445
500 Chesterfield Center, Suite 300, Chesterfield, MO 63017, p 636.728.1034, f 636.728.1035
6501 E. Commerce, Suite 230, Kansas City, MO 64120, p 816.231.4333, f 816.231.5641
812 Swifts Highway, Jefferson City, MO 65109, p 573.634.8109, f 573.634.8224
5460 Ward Road, Suite 110, Arvada, Colorado 80002, p 303.456.0400, f 303.456.0232
4389 South 500 West, Suite B, Salt Lake City, Utah 84123, p 801.261.8324, f 801.261.8420
www.forrestergroup.com

The conclusion of this discussion is that significant data exists to demonstrate that the two northern-area plumes discharge to the 21st Street Pond. The southern plume, if mobile, is also strongly indicated to discharge to the 21st Street Pond.

PAH / BTEX Plume above DNAPL at 21st Pond.

A groundwater plume impacted by PAHs and BTEX compounds is associated with residual DNAPL retained on the Alpine Formation adjacent to the southeast edge of the Pond. The groundwater potentiometric maps for this area (i.e., October 2000, January 2001, April 2001, July 2001) show that groundwater is flowing toward and ultimately discharges to the Pond. Thus the Pond appears to be a significant sink or point of discharge for shallow impacted groundwater.

As part of the 21st Street Pond RI, a groundwater flow model was developed for this area which was successfully calibrated to available hydraulic data. The model included the 21st Pond, portions of the Weber and Ogden Rivers south and north of the Pond, respectively, and numerous wells located south and east of the Pond. A water budget was established that balanced inflows to the Pond from groundwater and surface water (from the Ogden River via a man-made conduit) and outflows from the Pond to groundwater and surface water (to the Ogden River via a man-made outfall). Model output indicates that groundwater comprises the vast majority of inflows to the Pond (approximately 620 out of 720 gallons per minute or 86%). Outflows from the Pond via the surface water outfall are estimated to comprise 713 out of 720 gallons per minute or 99% of the total discharge from the 21 Street Pond.

Thus the 21st Pond represents a volumetrically significant point of discharge for groundwater and provides hydraulic capture of groundwater upgradient of the plume.

Northern Area VC Plume

The northern area vinyl chloride plume is located south and east of groundwater impacted by DNAPL and is subject to the same capture as the PAH / BTEX plume, due to the hydraulic influence of the 21st Street Pond.

Review of potentiometric surface maps (referenced above) indicates a consistent groundwater flow from south to north toward the 21st Street Pond over a distance of approximately 3,500 feet. Over this distance from south to north, water elevations fall from approximately 4,285 to 4,270 feet above mean sea level, respectively. Water levels are highest in April and lowest in October and January, though the hydraulic gradients appear to be relatively consistent throughout the year.

Furthermore, the hydraulic gradient in the northern part of Area 1 (near the 21st Street Pond) appears to be more steep (0.007 ft/ft) than in the southern part of Area 1 (0.005 ft/ft). Utilizing Darcy's Law and assuming that the hydraulic conductivity and porosity remain constant, a steeper hydraulic gradient indicates increased groundwater flow velocity. This increased gradient further illustrates that the 21st Street Pond is a strong hydraulic sink.

Comparison of Weber River and nearby well water-level elevations, as presented in the RI Report, indicates that the Weber River is generally a losing stream in the area of AOI-34 where monitoring was conducted. This is consistent with the conceptual model developed by Price (1985) for streams of the Wasatch Front. The water level in the Ogden River is also elevated with regard to the 21st Street Pond, to which stream flow is diverted by a man-made culvert. Loosing conditions preclude the discharge of both northern-area plumes to the Weber and Ogden Rivers and provide head for groundwater discharge to the 21st Street Pond.

These considerations, in conjunction with modeling results discussed above, strongly indicate that the northern area vinyl chloride plume is discharging to the 21st Street Pond.

Southern Area VC Plume

The southern area vinyl chloride plume is located south of the northern VC plume and approximately 6,000 to 7,500 feet south of the 21st Street Pond. The Weber River is located approximately 800 feet west of the plume.

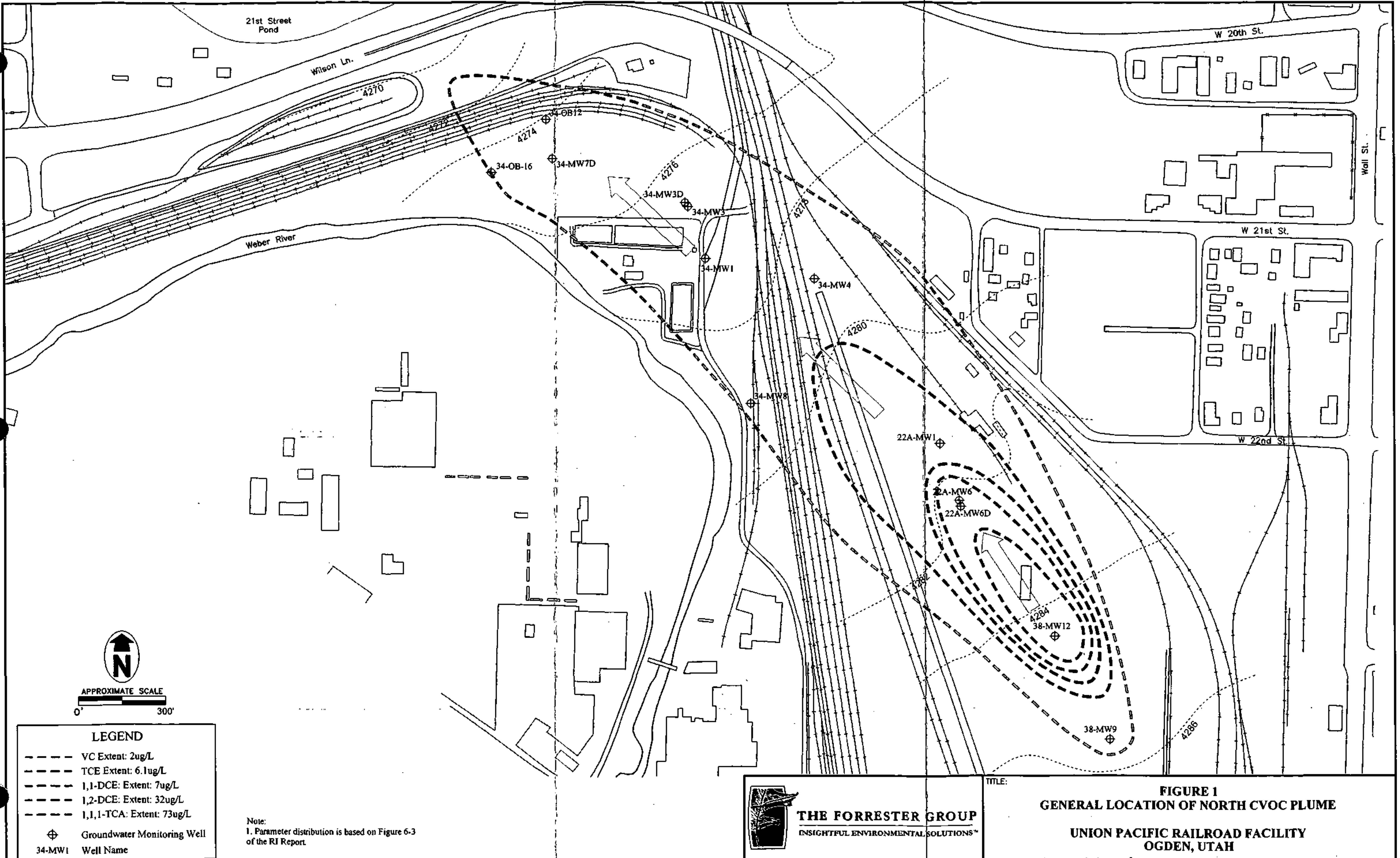
Review of potentiometric maps (referenced above) indicates that groundwater flow is toward the north. Within this Area water level elevations fall from approximately 4300 to 4290 feet (October 2000 and January 2001), though water levels were approximately 1 to 2 feet higher in April 2001. The hydraulic gradient averages approximately 0.006 ft/ft and appears to remain relatively constant throughout the year.

The plume is strongly influenced by the Weber River. Based upon data from AOI-34 and the conceptual model for streams of the Wasatch front developed by Price (1985), the Weber River is believed to be a loosing stream which precludes discharge of the plume to the river. Instead groundwater is flowing toward the north where it most likely will discharge to the 21st Street Pond. No other prospective discharge point for this plume, if mobile, has been identified.

Relatively little groundwater elevation data exists between the southern and northern areas due to a lack of wells. However, existing water level data indicate that consistent heads likely exist between these areas. Furthermore, there is no reason to believe that these two areas are hydraulically separate. In particular these areas exhibit similar stratigraphy and hydrogeological characteristics and no discontinuity, such as a stratigraphic pinch-out or fault, is known to exist. Therefore, it is reasonable to believed that groundwater from Area 2 will eventually flow to Area 1 and then discharge to the 21st Street Pond.

Summary

Review of site-specific water-level data, considered in context of regional hydrogeologic conceptual models and informed by numerical modeling, demonstrates that the two northern-area plumes discharge to the 21st Street Pond. The southern plume, if mobile, is also strongly indicated to ultimately discharge to the 21st Street Pond.



LEGEND

- VC Extent: 2ug/L
- TCE Extent: 6.1ug/L
- 1,1-DCE: Extent: 7ug/L
- 1,2-DCE: Extent: 32ug/L
- 1,1,1-TCA: Extent: 73ug/L
- Groundwater Monitoring Well
- 34-MW1 Well Name

Note:
1. Parameter distribution is based on Figure 6-3 of the RI Report.

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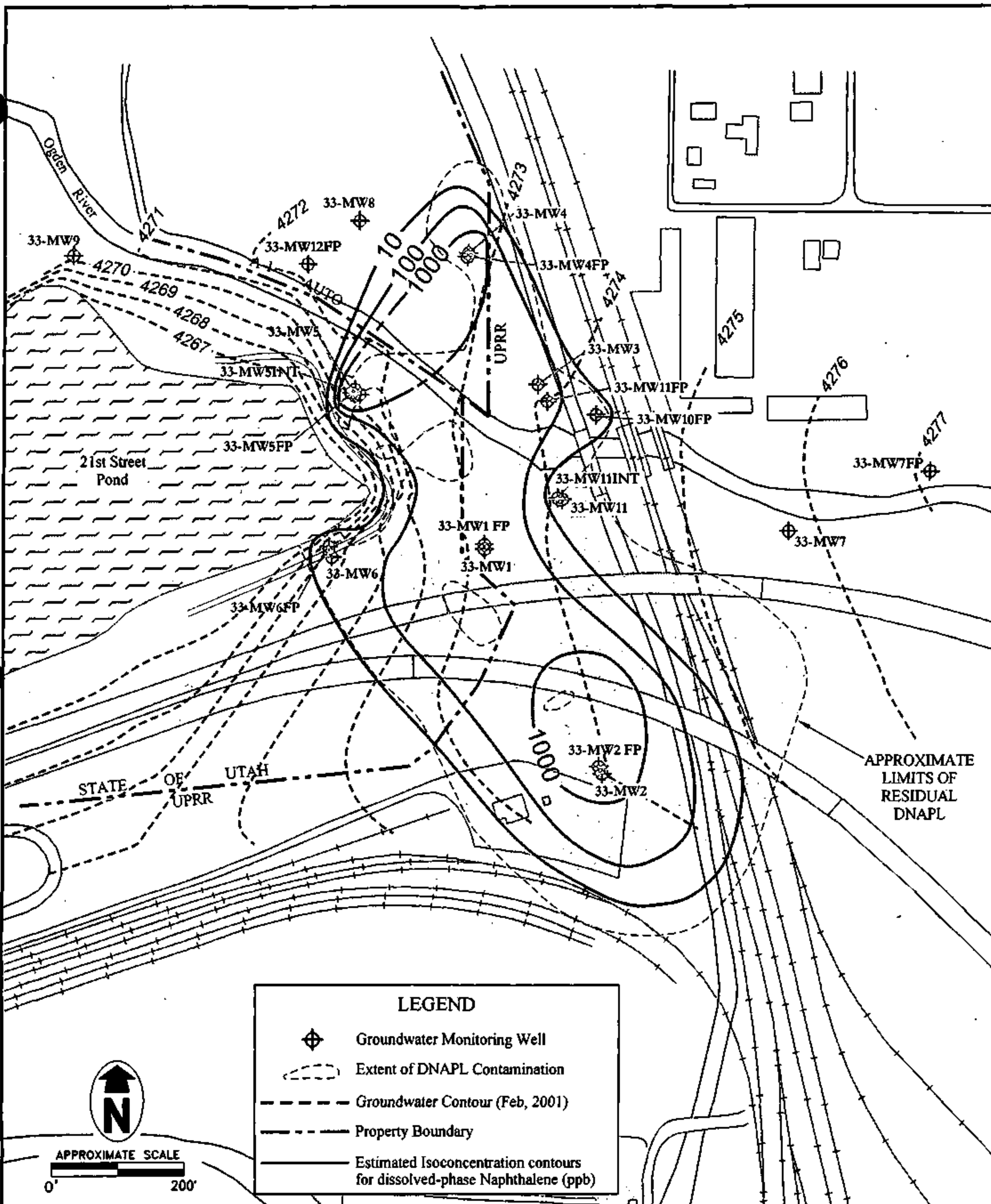
TITLE:

FIGURE 1
GENERAL LOCATION OF NORTH CVOC PLUME

UNION PACIFIC RAILROAD FACILITY
OGDEN, UTAH

1330-pX1.dwg 2453279.6673963



THE FORRESTER GROUP

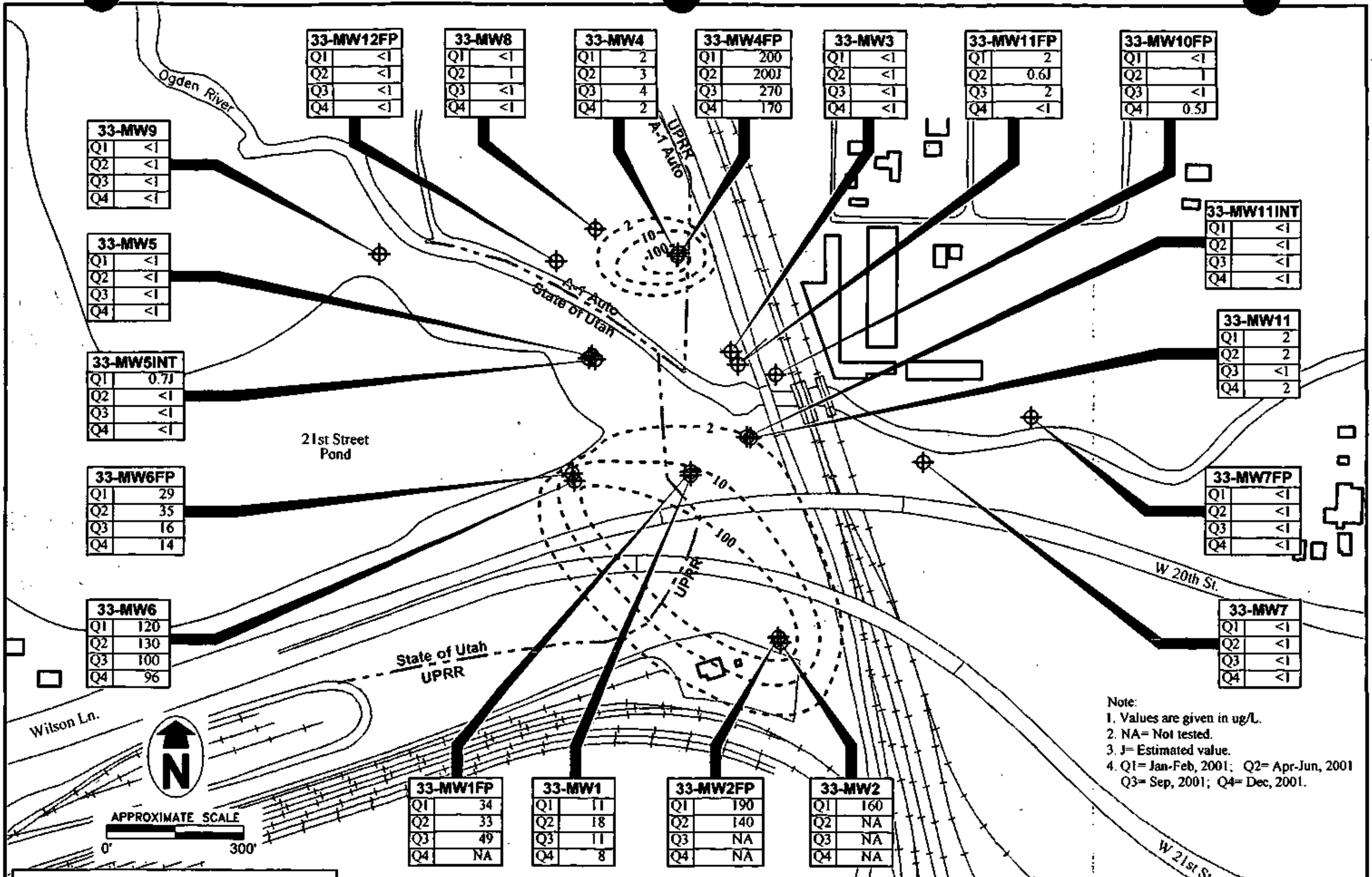
INSIGHTFUL ENVIRONMENTAL SOLUTIONS™

TITLE:

FIGURE 2
DISTRIBUTION OF DISSOLVED PHASE PAHs

UNION PACIFIC RAILROAD FACILITY
OGDEN, UTAH

1330-pX1.dwg 2453279.6673963



Note:
1. Values are given in ug/L.
2. NA= Not tested.
3. J= Estimated value.
4. Q1= Jan-Feb, 2001; Q2= Apr-Jun, 2001
Q3= Sep, 2001; Q4= Dec, 2001.

LEGEND

- Groundwater Monitoring Well
- - -10- - Estimated Benzene Isocontour (based on 12/01 data in ug/L)
- — · — Approximate Property Boundary

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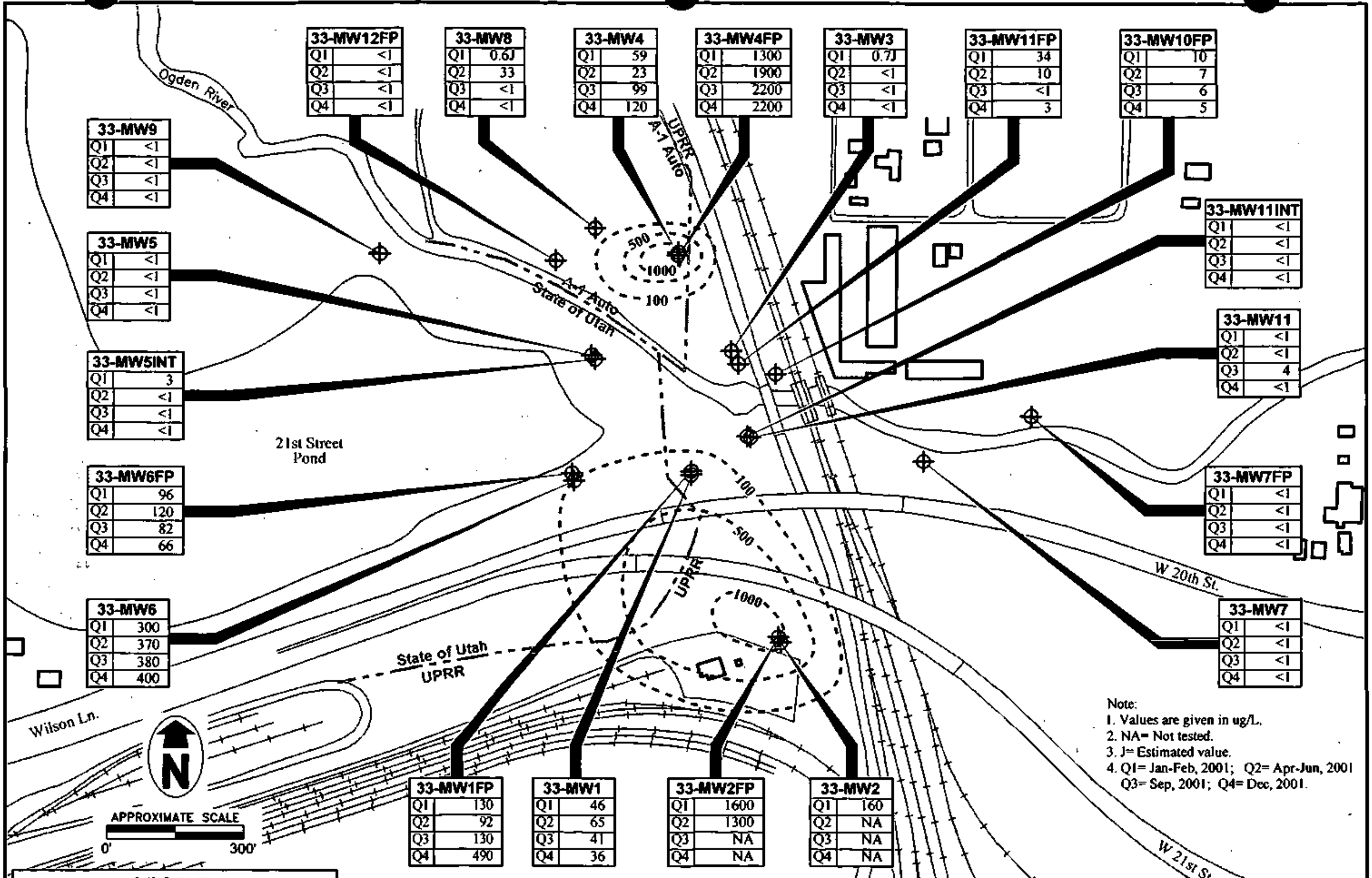
TITLE:

FIGURE 3.
BENZENE CONCENTRATIONS IN NORTHERN AREA GROUNDWATER
UNION PACIFIC RAILROAD FACILITY
OGDEN, UTAH

1330-05



LEGEND

- ⊕ Groundwater Monitoring Well
- - -10- - Estimated Ethylbenzene Isocontour (based on 12/01 data in ug/L)
- —··— Approximate Property Boundary

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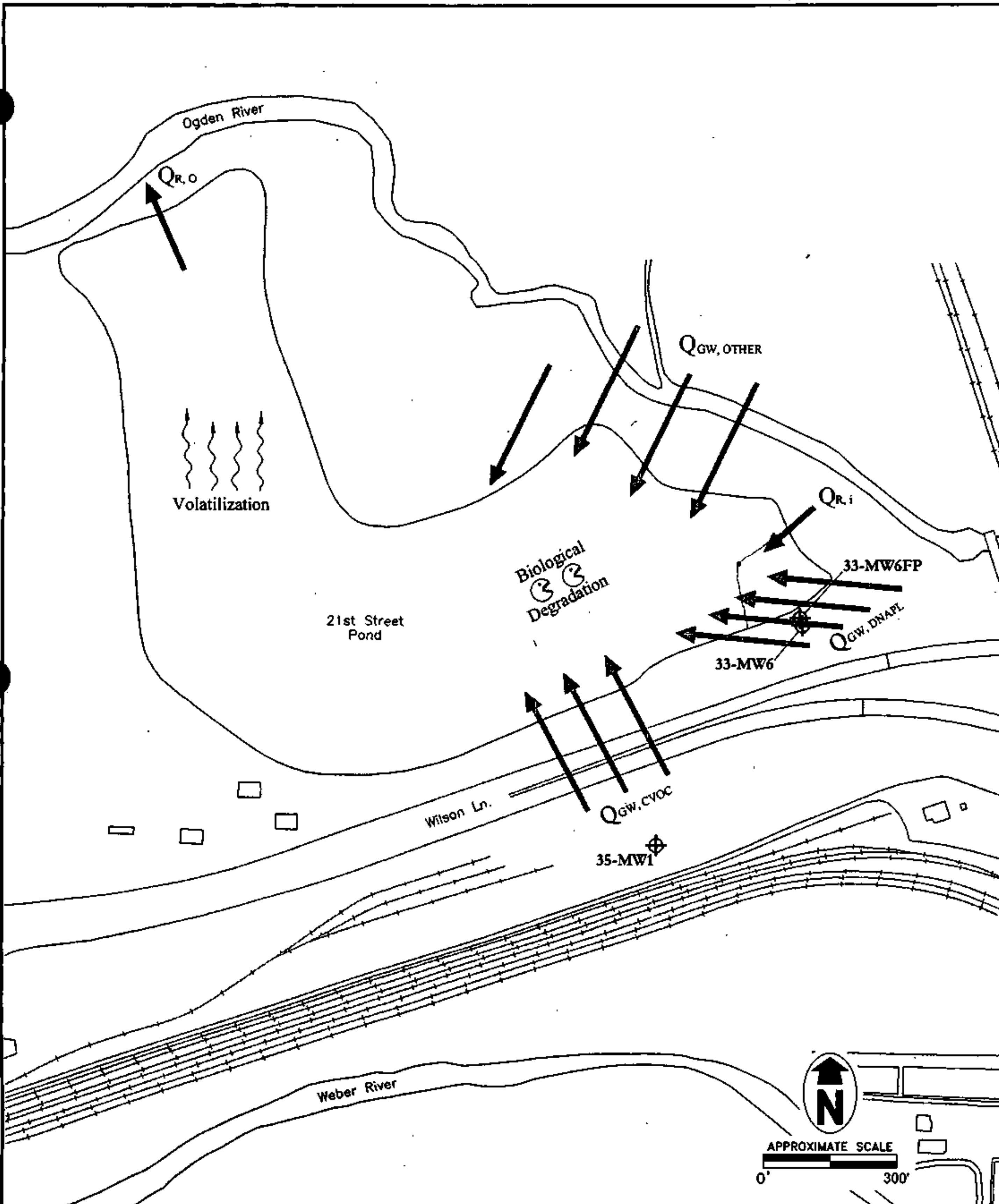
TITLE:

FIGURE 4
ETHYLBENZENE CONCENTRATIONS IN NORTHERN AREA GROUNDWATER
UNION PACIFIC RAILROAD FACILITY
OGDEN, UTAH

1330-05



THE FORRESTER GROUP

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TITLE:

FIGURE 5
CONCEPTUAL MODEL OF POND
FOR ACL DEMONSTRATION
UNION PACIFIC RAILROAD FACILITY
OGDEN, UTAH

1330-X1.dwg 2453277.79005695

APPENDIX G
EXAMPLE INSTITUTIONAL CONTROLS

MEMORANDUM

THE FORRESTER GROUP
INSIGHTFUL ENVIRONMENTAL SOLUTIONS

Date: October 30, 2003

To: File

From: Hoyt Sutphin

Subject: Ogden Railroad Facility
Institutional Controls

An integral part of the remedial action alternatives being considered for the Northern Area (OU-01) involves the incorporation of institutional controls to prevent human exposure to contaminated media.

Each of the alternatives removes or isolates the exposure risk to acceptable levels based on the current site use. However, dissolved constituents in groundwater will remain at concentrations above drinking water criteria (the uppermost aquifer at Ogden is classified a potential drinking water aquifer), and institutional control(s) that prohibit groundwater use on the properties where constituents are present are required to control the exposure pathway(s).

In the area of the 21s Street pond, these controls will be required on four different categories of property affected by the subsurface DNAPL contamination

- Property owned by UPRR (operating rail yard)
- Property owned by UDOT (20th and 21st Street overpass embankment areas)
- Property owned by UDOT (21st Street Park area planned for resumed recreational use)
- Property owned by A-One (auto parts salvage yard)

The mechanism of the institutional controls could include deed notices, deed restrictions, and/or restrictive covenants. A new section of the Utah Environmental Quality Code (Environmental Institutional Control Act Utah Code Sections 19-10-101) signed into law in 2003, provides a mechanism to make and impose upon subject properties institutional controls. Draft versions of an Environmental Notice and Institutional Control are provided for the four subject properties listed above.

DRAFT
After recording, return to:

A-One, Incorporated
Harlan Taylor
555 West 17th Street
Ogden, Utah 84404

With copy to:

Executive Director
Utah Department of Environmental Quality
168 North 1950 West
P.O. Box 144840
Salt Lake City, UT 84114-4840

Facility No. ____________________________
Location: Ogden, Utah

ENVIRONMENTAL NOTICE AND INSTITUTIONAL CONTROL

Pursuant to the Utah Environmental Institutional Control Act (Utah Code Sections 19-10-101, et seq.), Harlan Taylor ("Owner" herein), owner of the property located at 555 West 17th Street, in the City of Ogden, Weber County, State of Utah ("Property" herein; more particularly described on Attachment A which is attached hereto and by this reference made a part hereof) hereby makes and imposes upon the Property the following described Institutional Control, subject to the terms and conditions herein stated:

1. Notice is hereby given that the portion of the Property shown in Attachment A is or may be contaminated with hazardous materials as described below and, therefore, Institutional control(s) must be imposed to mitigate the risk to the public health, safety and/or the environment:

   A zone of dense non-aqueous phase hydrocarbon liquid (DNAPL) has been identified below groundwater in subsurface soils at general depths ranging from 17 to 25 feet below ground surface. Following a remedial investigation conducted by Union Pacific Railroad and overseen by USEPA under CERCLA protocol, a baseline risk assessment was conducted by the USEPA (Region 8). The risk assessment concluded that impacted groundwater would pose a substantial risk from direct ingestion of water and/or inhalation of VOCs released from water, if it were ever used for drinking or other indoor purposes. Direct human contact with the DNAPL contamination in subsurface soils may also present an adverse exposure risk.

   The risk is driven mainly by the following contaminants found in the subsurface soil and groundwater: benzene, ethylbenzene, benzo(a)pyrene, and naphthalene.

Attachment A shows the horizontal extent of contamination with respect to the parts of the Property subject to the Institutional Control.

Information on related investigation reports, remedial plans, and maintenance plans may be reviewed at the public document repository for CERCLA-8-99-12, located at Weber County Environmental Affairs, Weber Center, 2380 Washington Blvd., #359, Ogden, UT 84401

2. Use of the Property as shown on Attachment A is hereby restricted by the following Institutional Control(s):

Use of groundwater, including the installation of wells for this purpose is prohibited.

Excavations to depths below 17 feet where soil contaminated with residual DNAPL hydrocarbons may be encountered must be conducted under an appropriate Health and Safety Plan that includes provisions for work protection and appropriate testing and disposal of contaminated soil and groundwater removed from the excavation.

Use restrictions do not apply to excavation, drilling, or other activities performed on behalf of UPRR to implement any remediation activities as required by the USEPA Record of Decision for the site.

3. The above described Institutional Control(s) shall be, operated and maintained in perpetuity as follows unless terminated or modified as provided in Utah Code Section 19-10-105:

With prior notification and arrangement with the Owner, UPRR (its successors or contractors) shall be granted access to the area shown in Attachment A to conduct monitoring, sampling, and other activities related to remediation and monitoring of the DNAPL zone as required by the USEPA Record of Decision for the site.

4. This Institutional Control runs with the land and is binding on all successors in interest of the Owner unless or until it is removed as provided in Utah Code Section 1910-105.

5. The Executive Director of the Utah Department of Environmental Quality, or his/her designated representative, shall have access to the Property at all reasonable times to verify that this Institutional Control is being maintained and that the party or parties in possession of the Property are complying with the Institutional Control.

6. This Institutional Control may be enforced and/or protected as provided In Utah Code Section 1 9-10-106.

7. Instruments which convey any interest in the Property (fee, leasehold, easement,

etc.,) shall contain a notification to the person or entity which acquires the Interest that the Property is subject to this Environmental Notice and Institutional Control and identify the specific place at which it is recorded.

8. This Institutional Control may only be terminated in accordance, with the provisions of Utah Code Section 19-10-105 and with the prior written approval of the Executive Director of the Utah Department of Environmental Quality.

EXECUTED as of the ____ day of _________, 20__

____
[Owner]

___________________________________, Executive Director of the Utah Department of Environmental Quality, or his/her designated representative, hereby approves the foregoing Institutional Control pursuant to Utah Code Section 19-10-103.

____
Executive Director,
Utah Department of Environmental Quality

STATE OF UTAH)
) ss.
County of __________)

On the _______ day of _____________. 20 _____, personally appeared before me _________________________, the owner named in the foregoing I\instrument who duly acknowledged to me that he executed the same.

____
Notary Public, residing at:

____

____

My Commission expires: ______________________________

STATE OF UTAH)

) ss.
County of __________)

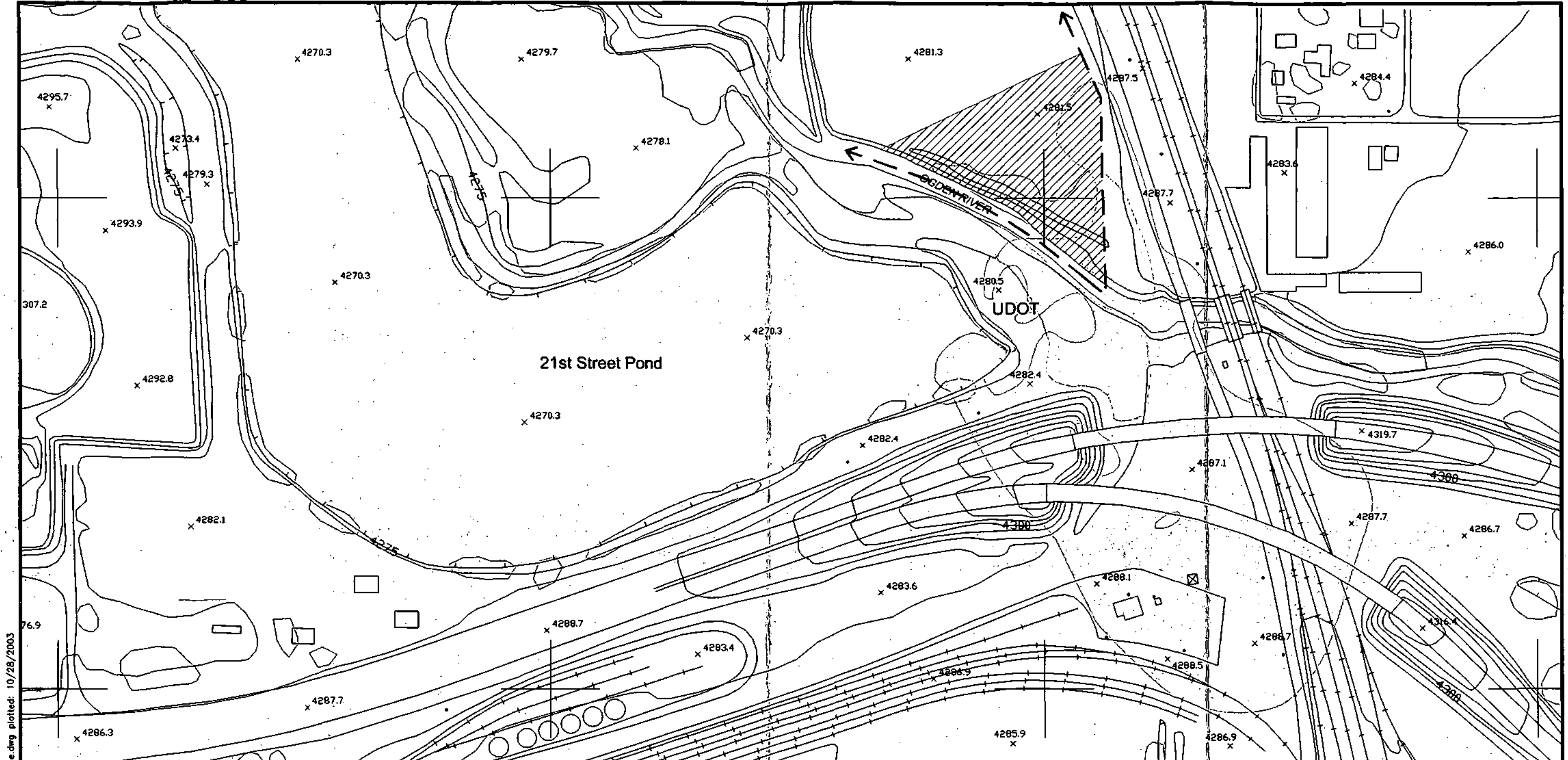
Subscribed and sworn to and acknowledged before me this _____ day of _____________, 20 ____, by Executive Director of the Utah Department of Environmental Quality, or his/her designated representative.

____
Notary Public, residing at:

____

____

My Commission expires: ________________________



LEGEND

BOUNDARY OF PROPERTY OWNED BY HARLAN TAYLOR

ZONE OF CONTAMINATION

PORTION OF PROPERTY UNDER INSTITUTIONAL CONTROL FOR EXCAVATION

NORTH

0 200 400
FEET

	BY	DATE
DRAWN	RJV	10/28/03
CHECKED		
APPROVED		
APPROVED		
APPROVED		

THE FORRESTER GROUP
INSIGHTFUL ENVIRONMENTAL SOLUTIONS™

UPRR RAILYARD - OGDEN, UTAH
ATTACHMENT A
EIC A-ONE

SCALE: 1"=200'
DWG. NO.: EIC-A-One.dwg

M:\clients\FORREST\Ogden\pintchgas\EIC-A-One.dwg plotted: 10/28/2003

DRAFT
After recording, return to:

Utah Department of Transportation
[Name]__________________
4501 South 2700 West
Salt Lake City, Utah 84114

With copy to:

Executive Director
Utah Department of Environmental Quality
168 North 1950 West
P.O. Box 144840
Salt Lake City, UT 84114-4840

Facility No. ____________________________
Location: Ogden, Utah

ENVIRONMENTAL NOTICE AND INSTITUTIONAL CONTROL

Pursuant to the Utah Environmental Institutional Control Act (Utah Code Sections 19-10-101, et seq.), Utah Department of Transportation ("Owner" herein), owner of the highway right of way located at approximately 550 West 21st Street, in the City of Ogden, Weber County, State of Utah ("Property" herein; more particularly described on Attachment A which is attached hereto and by this reference made a part hereof) hereby makes and imposes upon the Property the following described Institutional Control, subject to the terms and conditions herein stated:

1. Notice is hereby given that the portion of the Property shown in Attachment A is or may be contaminated with hazardous materials as described below and, therefore, Institutional control(s) must be imposed to mitigate the risk to the public health, safety and/or the environment:

   A zone of dense non-aqueous phase hydrocarbon liquid (DNAPL) has been identified below groundwater in subsurface soils at general depths ranging from 11 to 19 feet below ground surface as measured from the base of the overpass embankments. Following a remedial investigation conducted by Union Pacific Railroad and overseen by USEPA under CERCLA protocol, a baseline risk assessment was conducted by the USEPA (Region 8). The risk assessment concluded that impacted groundwater would pose a substantial risk from direct ingestion of water and/or inhalation of VOCs released from water, if it were ever used for drinking or other indoor purposes. Direct human contact with the DNAPL contamination in subsurface soils may also present an adverse exposure risk.

DRAFT

The risk is driven mainly by the following contaminants found in the subsurface soil and groundwater: benzene, ethylbenzene, benzo(a)pyrene, and naphthalene. Attachment A shows the horizontal extent of contamination with respect to the parts of the Property subject to the Institutional Control.

Information on related investigation reports, remedial plans, and maintenance plans may be reviewed at the public document repository for CERCLA-8-99-12, located at Weber County Environmental Affairs, Weber Center, 2380 Washington Blvd., #359, Ogden, UT 84401

2. Use of the Property as shown on Attachment A is hereby restricted by the following Institutional Control(s):

Use of groundwater, including the installation of wells for this purpose is prohibited.

Excavations to depths below 11 feet (as determined from the ground elevation at the base of the overpass embankments) where soil contaminated with residual DNAPL hydrocarbons, or groundwater, may be encountered must be conducted under an appropriate Health and Safety Plan that includes provisions for work protection and appropriate testing and disposal of contaminated soil and groundwater removed from the excavation.

3. The above described Institutional Control(s) shall be, operated and maintained in perpetuity as follows unless terminated or modified as provided in Utah Code Section 19-10-105.

4. This Institutional Control runs with the land and is binding on all successors in interest of the Owner unless or until it is removed as provided in Utah Code Section 1910-105.

5. The Executive Director of the Utah Department of Environmental Quality, or his/her designated representative, shall have access to the Property at all reasonable times to verify that this Institutional Control is being maintained and that the party or parties in possession of the Property are complying with the Institutional Control.

6. This Institutional Control may be enforced and/or protected as provided In Utah Code Section 1 9-10-106.

7. Instruments which convey any interest in the Property (fee, leasehold, easement, etc.,) shall contain a notification to the person or entity which acquires the Interest that the Property is subject to this Environmental Notice and Institutional Control and identify the specific place at which it is recorded.

8. This Institutional Control may only be terminated in accordance, with the provisions of Utah Code Section 19-10-105 and with the prior written approval of the Executive Director of the Utah Department of Environmental Quality.

DRAFT

EXECUTED as of the ____ day of _________, 20__.

____

[Owner]

____________________________________, Executive Director of the Utah Department of Environmental Quality, or his/her designated representative, hereby approves the foregoing Institutional Control pursuant to Utah Code Section 19-10-103.

____

Executive Director,
Utah Department of Environmental Quality

STATE OF UTAH)
) ss.
County of __________)

On the _______ day of _____________. 20 _____, personally appeared before me ________________________, the owner named in the foregoing I\instrument who duly acknowledged to me that he executed the same.

____

Notary Public, residing at:

____

____

My Commission expires: ______________________________

STATE OF UTAH)
) ss.
County of __________)

Subscribed and sworn to and acknowledged before me this ______ day of _______________, 20 _____, by Executive Director of the Utah Department of Environmental

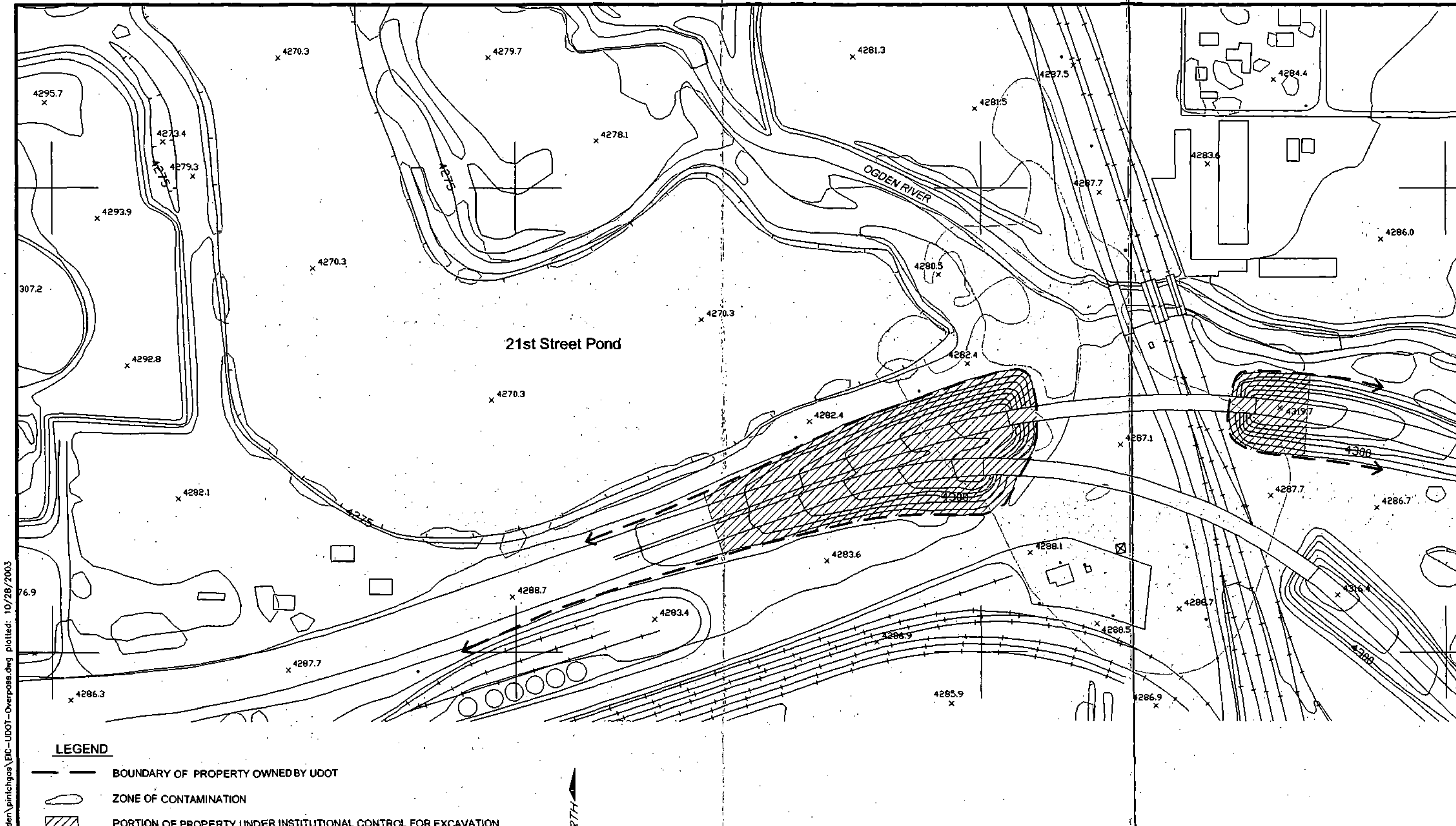
Quality, or his/her designated representative.

____
Notary Public, residing at:

____

____

My Commission expires: ________________________



	BY	DATE
DRAWN	RJV	10/28/03
CHECKED		
APPROVED		
APPROVED		
APPROVED		

THE FORRESTER GROUP
INSIGHTFUL ENVIRONMENTAL SOLUTIONS™

UPRR RAILYARD - OGDEN, UTAH
ATTACHMENT A
EIC UDOT OVERPASS

SCALE: 1"=200'
DWG. NO.: EIC-UDOT-Overpass.dwg

DRAFT
After recording, return to:

Utah Department of Transportation
[Name]______________
4501 South 2700 West
Salt Lake City, Utah 84114

With copy to:

Executive Director
Utah Department of Environmental Quality
168 North 1950 West
P.O. Box 144840
Salt Lake City, UT 84114-4840

Facility No. ______________________
Location: Ogden, Utah

ENVIRONMENTAL NOTICE AND INSTITUTIONAL CONTROL

Pursuant to the Utah Environmental Institutional Control Act (Utah Code Sections 19-10-101, et seq.), Utah Department of Transportation ("Owner" herein), owner of the property located at 620 West 20th Street, in the City of Ogden, Weber County, State of Utah ("Property" herein; more particularly described on Attachment A which is attached hereto and by this reference made a part hereof) hereby makes and imposes upon the Property the following described Institutional Control, subject to the terms and conditions herein stated:

1. Notice is hereby given that the portion of the Property shown in Attachment A is or may be contaminated with hazardous materials as described below and, therefore, Institutional control(s) must be imposed to mitigate the risk to the public health, safety and/or the environment:

A zone of dense non-aqueous phase hydrocarbon liquid (DNAPL) has been identified below groundwater in subsurface soils at general depths ranging from 12 to 25 feet below ground surface. Following a remedial investigation conducted by Union Pacific Railroad and overseen by USEPA under CERCLA protocol, a baseline risk assessment was conducted by the USEPA (Region 8). The risk assessment concluded that impacted groundwater would pose a substantial risk from direct ingestion of water and/or inhalation of VOCs released from water, if it were ever used for drinking or other indoor purposes. Direct human contact with the DNAPL contamination in subsurface soils and capped sediments in the SE corner of the 21st Street pond may also present an adverse exposure risk.

The risk is driven mainly by the following contaminants found in the subsurface

DRAFT

soil and groundwater: benzene, ethylbenzene, benzo(a)pyrene, and naphthalene. Attachment A shows the horizontal extent of contamination with respect to the parts of the Property subject to the Institutional Control.

Information on related investigation reports, remedial plans, and maintenance plans may be reviewed at the public document repository for CERCLA-8-99-12, located at Weber County Environmental Affairs, Weber Center, 2380 Washington Blvd., #359, Ogden, UT 84401

2. Use of the Property as shown on Attachment A is hereby restricted by the following Institutional Control(s):

Use of groundwater, including the installation of wells for this purpose is prohibited over the entire area of the property south of the Ogden River.

Excavations to depths greater than 5 feet below the ground surface are restricted in the area shown on Attachment 1. Any excavation below 5 feet in this area must be conducted under an appropriate Health and Safety Plan that includes provisions for worker protection and appropriate testing and disposal of contaminated soil and groundwater removed from the excavation. Any such excavations must not directly or indirectly impact the engineered remedial controls implemented by UPRR as required by the CERCLA record of decision.

No excavation or alteration of land surface, ground, or pond bank is permitted in the area of the engineered cap shown in Attachment A.

Use restrictions do not apply to excavation, drilling, or other activities performed on behalf of UPRR to implement any remediation activities as required by the USEPA Record of Decision for the site.

3. The above described Institutional Control(s) shall be, operated and maintained in perpetuity as follows unless terminated or modified as provided in Utah Code Section 19-10-105:

With prior notification and arrangement with the Owner, UPRR (its successors or contractors) shall be granted access to the area shown in Attachment A to conduct monitoring, sampling, maintenance, repair, and other activities related to remediation and monitoring of the DNAPL zone as required by the USEPA Record of Decision for the site.

4. This Institutional Control runs with the land and is binding on all successors in interest of the Owner unless or until it is removed as provided in Utah Code Section 1910-105.

5. The Executive Director of the Utah Department of Environmental Quality, or his/her designated representative, shall have access to the Property at all reasonable times to verify that this Institutional Control is being maintained and that the party or

parties in possession of the Property are complying with the Institutional Control.

6. This Institutional Control may be enforced and/or protected as provided In Utah Code Section 1 9-10-106.

7. Instruments which convey any interest in the Property (fee, leasehold, easement, etc.,) shall contain a notification to the person or entity which acquires the Interest that the Property is subject to this Environmental Notice and Institutional Control and identify the specific place at which it is recorded.

8. This Institutional Control may only be terminated in accordance, with the provisions of Utah Code Section 19-10-105 and with the prior written approval of the Executive Director of the Utah Department of Environmental Quality.

EXECUTED as of the ____ day of _________, 20__

____

[Owner]

________________________________, Executive Director of the Utah Department of Environmental Quality, or his/her designated representative, hereby approves the foregoing Institutional Control pursuant to Utah Code Section 19-10-103.

____

Executive Director,
Utah Department of Environmental Quality

STATE OF UTAH)
) ss.
County of __________)

On the _______ day of _____________. 20 _____, personally appeared before me ______________________, the owner named in the foregoing I\instrument who duly acknowledged to me that he executed the same.

____

Notary Public, residing at:

____

____

DRAFT

My Commission expires: ______________________________

STATE OF UTAH)
) ss.
County of __________)

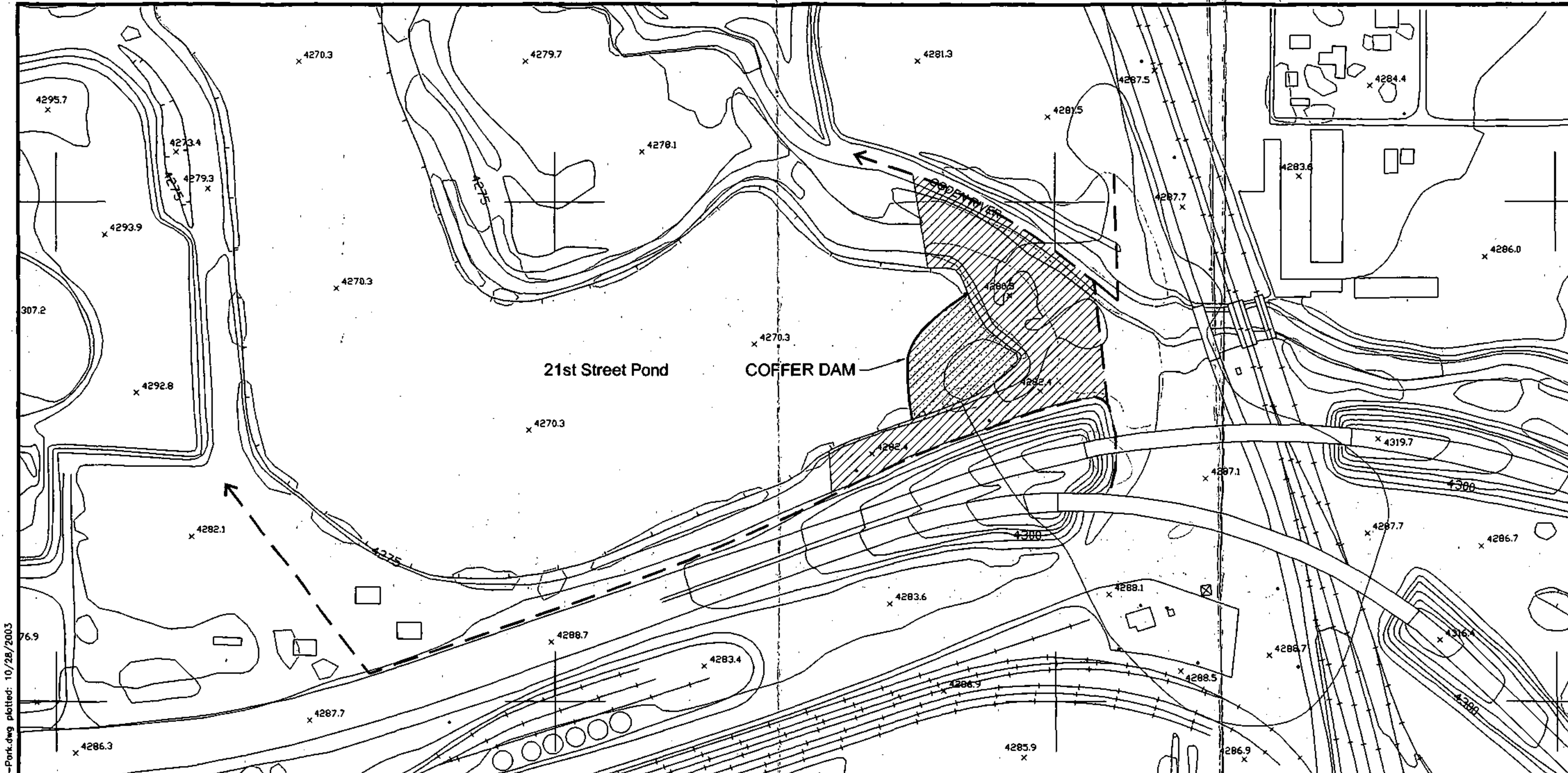
Subscribed and sworn to and acknowledged before me this ______ day of _______________, 20 _____, by Executive Director of the Utah Department of Environmental Quality, or his/her designated representative.

____
Notary Public, residing at:

____

____

My Commission expires: ______________________________



M:\clients\FORREST\Ogden\pinchgos\EIC-UDOT-Park.dwg plotted: 10/28/2003

LEGEND

- BOUNDARY OF PROPERTY AND LIMIT OF GROUNDWATER USE RESTRICTION
- ZONE OF CONTAMINATION
- PORTION OF PROPERTY UNDER INSTITUTIONAL CONTROL FOR EXCAVATION
- AREA OF CAPPED CONTAMINATION

NORTH

0 200 400
FEET

	BY	DATE
DRAWN	FR	10/27/03
CHECKED		
APPROVED		
APPROVED		
APPROVED		

THE FORRESTER GROUP
INSIGHTFUL ENVIRONMENTAL SOLUTIONS™

UPRR RAILYARD - OGDEN, UTAH
ATTACHMENT A
EIC UDOT PARK

SCALE: 1"=200'
DWG. NO.: EIC-UDOT-Park.dwg

DRAFT
After recording, return to:

Union Pacific Railroad Company
[Name]__________
1416 Dodge Street
Omaha, NE 68179

With copy to:

Executive Director
Utah Department of Environmental Quality
168 North 1950 West
P.O. Box 144840
Salt Lake City, UT 84114-4840

Facility No. ______________________________
Location: Ogden, Utah

ENVIRONMENTAL NOTICE AND INSTITUTIONAL CONTROL

Pursuant to the Utah Environmental Institutional Control Act (Utah Code Sections 19-10-101, et seq.), Union Pacific Railroad ("Owner" herein), owner of the Ogden Railroad Facility with an office located at 3311 Pacific Avenue, in the City of Ogden, Weber County, State of Utah ("Property" herein; more particularly described on Attachment A which is attached hereto and by this reference made a part hereof) hereby makes and imposes upon the Property the following described Institutional Control, subject to the terms and conditions herein stated:

1. Notice is hereby given that the portion of the Property shown in Attachment A is or may be contaminated with hazardous materials as described below and, therefore, Institutional control(s) must be imposed to mitigate the risk to the public health, safety and/or the environment:

A zone of dense non-aqueous phase hydrocarbon liquid (DNAPL) has been identified below groundwater in subsurface soils at general depths ranging from 13 to 22 feet below ground surface. During the remedial investigation, a baseline risk assessment was conducted by USEPA (Region 8). The risk assessment concluded that impacted groundwater would pose a substantial risk from direct ingestion of water and/or inhalation of VOCs released from water, if it were ever used for drinking or other indoor purposes. Direct human contact with the DNAPL contamination in subsurface soils may also present an adverse exposure risk.

The risk is driven mainly by the following contaminants found in the subsurface soil and groundwater: benzene, ethylbenzene, benzo(a)pyrene, and naphthalene. Attachment A shows the horizontal extent of contamination with respect to the parts of the Property subject to the Institutional Control.

Information on related investigation reports, remedial plans, and maintenance plans may be reviewed at the public document repository for CERCLA-8-99-12, located at Weber County Environmental Affairs, Weber Center, 2380 Washington Blvd., #359, Ogden, UT 84401

2. Use of the Property as shown on Attachment A is hereby restricted by the following Institutional Control(s):

Use of groundwater for residential or industrial purposes, including the installation of wells for this purpose is prohibited.

Excavations to depths below 13 feet where soil contaminated with residual DNAPL hydrocarbons may be encountered must be conducted under an appropriate Health and Safety Plan that includes provisions for work protection and appropriate disposal of contaminated soil and groundwater removed from the excavation.

Use restrictions do not apply to excavation, drilling, or other activities performed on behalf of UPRR to implement any remediation activities as required by the USEPA Record of Decision for the site.

3. The above described Institutional Control(s) shall be, operated and maintained in perpetuity as follows unless terminated or modified as provided in Utah Code Section 19-10-105.

4. This Institutional Control runs with the land and is binding on all successors in interest of the Owner unless or until it is removed as provided in Utah Code Section 1910-105.

5. The Executive Director of the Utah Department of Environmental Quality, or his/her designated representative, shall have access to the Property at all reasonable times to verify that this Institutional Control is being maintained and that the party or parties in possession of the Property are complying with the Institutional Control.

6. This Institutional Control may be enforced and/or protected as provided In Utah Code Section 1 9-10-106.

7. Instruments which convey any interest in the Property (fee, leasehold, easement, etc.,) shall contain a notification to the person or entity which acquires the Interest that the Property is subject to this Environmental Notice and Institutional Control and identify the specific place at which it is recorded.

8. This Institutional Control may only be terminated in accordance, with the provisions of Utah Code Section 19-10-105 and with the prior written approval of the Executive Director of the Utah Department of Environmental Quality.

DRAFT

EXECUTED as of the ____ day of _________, 20__

____
[Owner]

________________________________, Executive Director of the Utah Department of Environmental Quality, or his/her designated representative, hereby approves the foregoing Institutional Control pursuant to Utah Code Section 19-10-103.

____
Executive Director,
Utah Department of Environmental Quality

STATE OF UTAH)
) ss.
County of __________)

On the _______ day of ______________. 20 _____, personally appeared before me ______________________, the owner named in the foregoing I\instrument who duly acknowledged to me that he executed the same.

____
Notary Public, residing at:

____

____

My Commission expires: ______________________________

STATE OF UTAH)
) ss.
County of __________)

Subscribed and sworn to and acknowledged before me this ______ day of ______________, 20 _____, by Executive Director of the Utah Department of Environmental

DRAFT

Quality, or his/her designated representative.

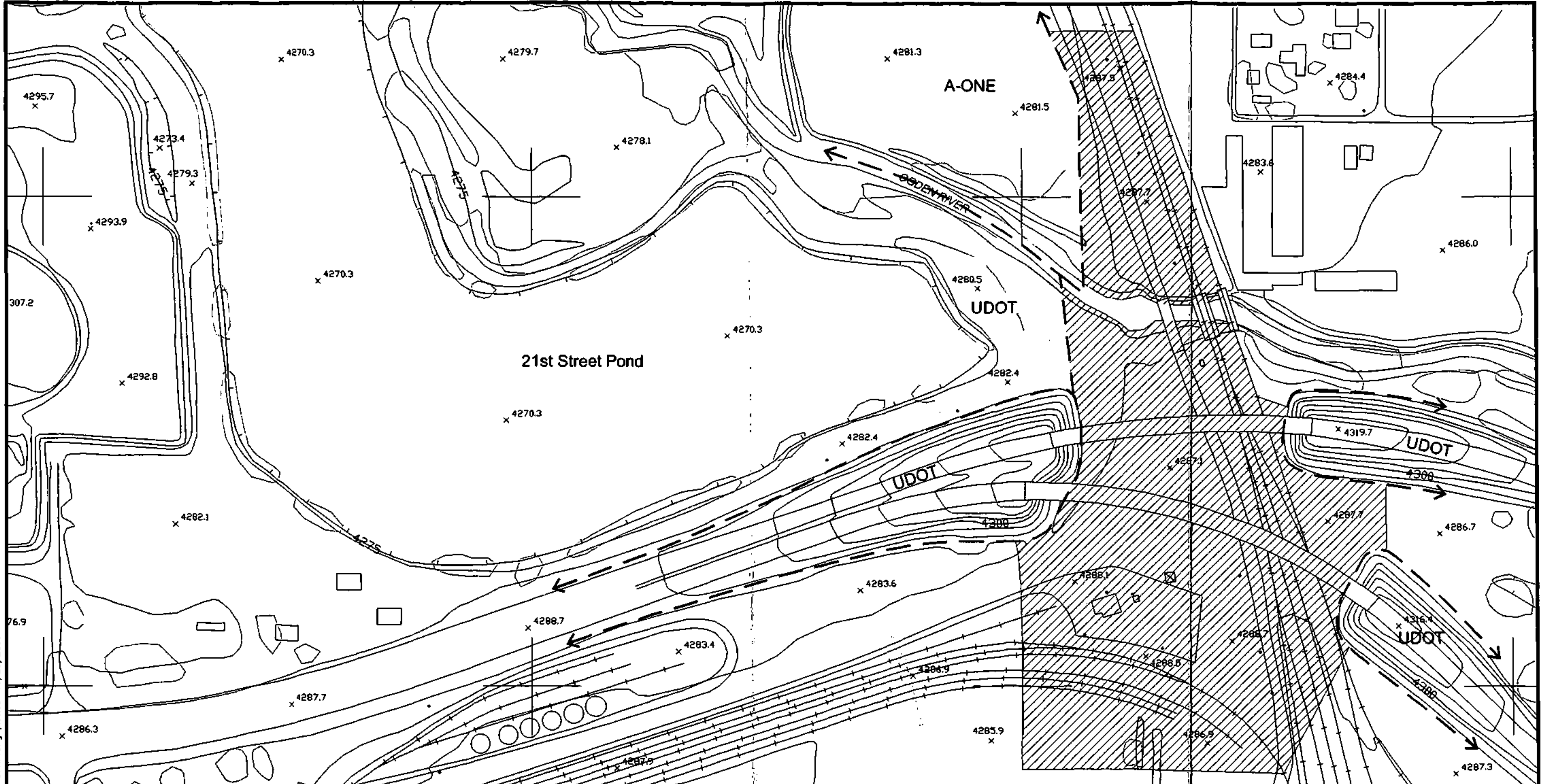
____

Notary Public, residing at:

____

____

My Commission expires: ______________________



LEGEND

BOUNDARY OF PROPERTY OWNED BY UPRR

ZONE OF CONTAMINATION

PORTION OF PROPERTY UNDER INSTITUTIONAL CONTROL FOR EXCAVATION

NORTH

0 200 400

FEET

	BY	DATE
DRAWN	RJV	10/28/03
CHECKED		
APPROVED		
APPROVED		
APPROVED		

THE FORRESTER GROUP
INSIGHTFUL ENVIRONMENTAL SOLUTIONS™

UPRR RAILYARD - OGDEN, UTAH
ATTACHMENT A
EIC UPRR

SCALE: 1"=200'

DWG. NO.: EIC-UPRR.dwg

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APPENDIX H
DETAILED COST ESTIMATES

UPRR Ogden, Utah Yard
September 2004
Comparison of Costs

Alternative		Total Cost	Time
Alternative 1: No Action	$	-	0
Alternative 2: Monitoring w/ Existing IC	$	500,000	0+30
Alternative 3: Contain Pond Sediments & DNAPL Recovery	$	1,607,000	1+3+30
Alternative 4: Excavate Pond Soils & Intensive DNAPL Recovery	$	50,430,000	2+6
Alternative 5: Excavate Pond Sediments and DNAPL Recovery	$	2,317,000	2+30

	A	B	C	D	E	F
1	**Cost Estimate- Alternative 2**					
2	***UPRR Ogden Rail Yard FS***					
3	**September 2004**					
4	**Alernative 2, DNAPL Monitoring**					
5						
6	**Item**	**Basis**	**Quantity**	**Unit**	**Unit Price**	**Ext Amount**
7	**Annual Monitoring, Years 1-5**					
8	Work Planning	Workplans, Logistics, Mobilizalton	1	ea	$ 6,900.00	$ 6,900
9	Semiannual Field Sampling	2 events, 3 days per event, 2 field staff	1	ea	$ 13,200.00	$ 13,200
10	Laboratory Analysis	14 wells VOCs per event, 14 wells PAHs per event	1	ea	$ 10,400.00	$ 10,400
11	Annual Reporting		1	ea	$ 10,200.00	$ 10,200
12					Subtotal	$ 40,700
13	Unscoped items	Allow 10 percent	10	PCT	$ 40,700	$ 4,100
14	**Contract cost**					$ 44,800
15	*Contingency*	*Allow 15 percent*	15	PCT	$ 44,800	$ 6,700
16					**Total**	**$ 51,500**
17					**Present Value**	**$ 211,160**
18	**Annual Monitoring, Years 6-30**					
19	Work Planning	Workplan, Health & Safety Plan, Mobilizalton	1	ea	$ 3,500.00	$ 3,500
20	Annual Field Sampling	1 event, 3 days per event, 2 field staff	1	ea	$ 6,600.00	$ 6,600
21	Laboratory Analysis	15 wells VOCs per event, 15 wells PAHs per event	1	ea	$ 5,200.00	$ 5,200
22	Annual Reporting	Assumed 0.5 * year 1-5 annual report	1	ea	$ 5,100.00	$ 5,100
23					Subtotal	$ 20,400
24	Unscoped items	Allow 10 percent	10	PCT	$ 20,400	$ 2,000
25	**Contract cost**					$ 22,400
26	Contingency	Allow 15 percent	15	PCT	$ 22,400	$ 3,400
27					**Total**	**$ 25,800**
28					**Present Value**	**$ 214,368**
29	**5 Year Periodic Costs**					
30	Five Year Review Report	Assumed 2.5 * year 1-5 annual repor	1	ea	$ 25,500.00	$ 25,500
31					Subtotal	$ 25,500
32	Unscoped items	Allow 10 percent	10	PCT	$ 25,500	$ 2,600
33	**Contract cost**					$ 28,100
34	Contingency	Allow 15 percent	15	PCT	$ 28,100	$ 4,200
35					**Total**	**$ 32,300**
36					**Present Value**	**$ 69,697**
37	**10 Year Periodic Costs**					
38	Monitoring Well Drilling	Assume 2 wells per 10 years	2	ea	$ 3,000.00	$ 6,000
39	Oversight & reporting	Installation oversight, well logs	1	ea	$ 2,300.00	$ 2,300
40					Subtotal	$ 8,300
41	Unscoped items	Allow 10 percent	10	PCT	$ 8,300	$ 800
42	**Contract cost**					$ 9,100
43	Contingency	Allow 15 percent	15	PCT	$ 9,100	$ 1,400
44					**Total**	**$ 10,500**
45					**Present Value**	**$ 9,430**
46						
47					**Present Value at 7% over 30 years**	**$ 504,656**
48					**Total Rounded to the nearest $10,000**	**$ 500,000**

	A	B	C	D	E	F
1	**Cost Estimate- Alternative 3**					
2	**UPRR Ogden, Utah Yard**					
3	**September 2004**					
4	**Alternative 3 - Containment**					
5						
6						
7	**Item**	**Basis**	**Quantity**	**Unit**	**Unit Price**	**Ext Amount**
8	**Coffer Dam**	350 ft long, 5 ft average height, 4:1 slopes, & key trench	1,750	SF	$ 18.60	$ 32,550
9	**Oil Control Boom**	Boom on downstream side of coffer dam	5	DAY	$ 500.00	$ 2,500
10	**Dewatering of Pond**	Dewatering, pumping 8 hr, 8 hrs attended, 6" centrifugal pump	4	DAY	$ 760.00	$ 3,040
11	**Dewatering During Construction**	Dewatering, pumping 8 hr, 8 hrs attended, 4" diaphragm pump	28	DAY	$ 610.00	$ 17,080
12	**Water Treatment During Construction**					
13	Baker Tanks	Assume two 23,000-gallon Baker Tanks, for rental	76	DAY	$ 95.00	$ 7,220
14	Polymer	Use polymer to assist in particle settling	1	LS	$ 2,000.00	$ 2,000
15	Sediment Removal	Chemicals and Labor to remove sediments from baker tanks	1	LS	$ 5,000.00	$ 5,000
16	Bag Filter	1 Bag Filter, Barnaby-Seteliff BF 300, rental	2.5	MO	$ 250.00	$ 625
17	Bags	Assume new bag each day	76	EA	$ 10.00	$ 760
18	Carbon Filter	2 Single Vessel Carbon Filters Model LS360, rental	2.5	MO	$ 2,780.00	$ 6,950
19	Carbon	Carbon for Carbon Vessels	10,000	LB	$ 1.00	$ 10,000
20	Carbon Filter Disposal	Disposal of carbon filter after construction	10,000	LB	$ 0.10	$ 1,000
21	Freight	Cost from freighting equipment from and back to NV	2	LS	$ 2,500.00	$ 5,000
25	**Excavation of DNAPL Trench**	Material will be blended into area to be covered	248	CCY	$ 4.56	$ 1,130
26	**Drain Trench**	Borrow, crsh stone, 3/4", ld at pit,haul 2 mi RT&sprd w/200 HP dozer	248	CCY	$ 24.00	$ 5,940
27	**Trench Pipe**	Piping, not including excavation or backfill, class 160, 6" diameter	297	LF	$ 9.65	$ 2,866
28	**DNAPL Sumps**	CB or manholes, conc, precast, 4' ID, 6' deep	1	EA	$ 1,500.00	$ 1,500
29	**DNAPL Pumps**	Assume pneumatic or anchor pump	0	EA	$ 5,000.00	$ -
30	**DNAPL Pump Controls**	Assume pump operates on timer	0	LS	$ 2,000.00	$ -
31	**DNAPL Piping**	2" carbon steel pipe, sch 40, welded, buried 36 inches	0	LF	$ 15.27	$ -
32	**DNAPL Storage Tank**	Tanks,st,double wall,abv grnd,w/sprts,mway,ftngs,no mat,ps,piping,2000gal	0	EA	$ 5,575.00	$ -
33	**Monitoring Wells**	2-in dia., 20' deep, 10' screen, 0.1 slot	2	EA	$ 3,000.00	$ 6,000
34	**Backfill**					
35	Layer 1	Borrow, crsh stone, 3/4", ld at pit,haul 2 mi RT&sprd w/200 HP dozer	1,280	CCY	$ 24	$ 30,724
36	Layer 2	Borrow, crsh stone, 3/4", ld at pit,haul 2 mi RT&sprd w/200 HP dozer	2,770	CCY	$ 24	$ 66,482
37	Layer 3	Borrow, crsh stone, 3/4", ld at pit,haul 2 mi RT&sprd w/200 HP dozer	1,602	CCY	$ 24	$ 38,440
38	Layer 4	Borrow, buy&ld at pit, haul 2 mi RT&sprd w/200 HP dozer, topsoil, weed free	1,602	CCY	$ 15	$ 24,270
39	**Electrical Transformer**	Power supply to construction site	1	LS	$ 10,000.00	$ 10,000
40	**Landscaping**	Seeding, hydro or air seeding for lg areas, incl seed and fertilizer	4,555	SY	$ 0.32	$ 1,458
41	**Subtotal**					$ 282,535
42	Unscoped items	Allow 10 percent	10	PCT	$ 282,535	$ 28,300
43	**Subtotal**					$ 310,835
44	General Requirements (Mob, bonds, insur)	Allow 10 percent	10	PCT	$ 310,835	$ 31,100
45	**Contract cost**					$ 341,935
46	Contingency	Allow no contingency	0	PCT	$ 341,935	$ -
47	**Construction Cost**					$ 341,935
48	Design	Allow 10 percent	10	PCT	$ 341,935	$ 34,200
49	Permitting	Allow 10 percent	10	PCT	$ 341,935	$ 34,200
50	Construction Oversight	Allow 10 percent	10	PCT	$ 341,935	$ 34,200
51	**Total**					$ 444,535
52	**Total Rounded to the nearest $10,000**					$ 440,000

	A	B	C	D	E	F
1	**Cost Estimate- Alternative 3**					
2	**UPRR Ogden, Utah Yard**					
3	**September 2004**					
4	**Alternative 3 - DNAPL Recovery**					
5						
6						
7	**Item**	**Basis**	**Quantity**	**Unit**	**Unit Price**	**Ext Amount**
8	*Recovery well installation*	*Completion of 3 additional recovery wells*	3	EA	$ 6,000.00	$ 18,000
9	Injection well installation	Completion of 3 additional injection wells	3	EA	$ 6,000.00	$ 18,000
10	Observation well installation	Completion of 9 additional observation wells	9	EA	$ 1,111.11	$ 10,000
11						
12	**Subtotal**					$ 46,000
13	Unscoped items	Allow 10 percent	10	PCT	$ 46,000	$ 4,600
14	**Contract cost**					$ 50,600
15	Contingency	Allow 10 percent	10	PCT	$ 50,600	$ 5,100
16	**Total**					$ 55,700
17	**Total Rounded to the nearest $10,000**					**$ 60,000**

	A	B	C	D	E	F
1	**Cost Estimate- Alternative 3**					
2	**UPRR Ogden, Utah Yard**					
3	**September 2004**					
4	**Alt 3 - Operation and Maintenance Costs**					
5						
6	**Item**	**Basis**	**Quantity**	**Unit**	**Unit Price**	**Ext Amount**
7	***Years 1 to 30 of MNA Total Present Worth***					
8	MNA Monitoring	Estimated Total Present Worth	1	LS	$ 500,000	**$ 500,000**
9	***Years 1 to 3 of DNAPL Recovery Present Worth***					
10	System up-grade, modifications, and maintenance	Over 3 year period	1	LS	$ 150,000.00	$ 150,000
11	System operation and monitoring	Over 3 year period	1	LS	$ 300,000.00	$ 300,000
12	**Subtotal**					**$ 450,000**
13						
14	***Years 1 to 30 of Operation***					
15	Monitoring of DNAPL Sumps	4 hrs per week	208	HR	$ 61	$ 12,688
21					**TOTAL**	**$ 12,688**
22						
23						
24			*Present Value at*		*7% over 30 years*	**$1,107,000**
25						
26	Assumptions:					
27	The level of effort to complete monitoring is consistent over time for 30 years.					

	A	B	C	D	E	F
1	**UPRR Ogden, Utah Yard**					
2	**September 2004**					
3	**Alternative 4 - Sediment Excavation in Pond**					
4						
5						
6	**Item**	**Basis**	**Quantity**	**Unit**	**Unit Price**	**Ext Amount**
10	**Excavation of Clean Fill**					
11	Excavation	Borrow topsoil from site and haul to on-site stockpile	2,484	CCY	$ 4.56	$ 11,339
12	**Coffer Dam**	350 ft long, 5 ft average height, 4:1 slopes, & key trench	1,750	SF	$ 18.60	$ 32,550
13	**Oil Control Boom**	Boom on downstream side of coffer dam	5	DAY	$ 500.00	$ 2,500
14	**Dewatering of Pond**	Dewatering, pumping 8 hr, 8 hrs attended, 6" centrifugal pump	0	DAY	$ 760.00	$ -
15	**Dewatering During Construction**	Dewatering, pumping 8 hr, 8 hrs attended, 4" diaphragm pump	0	DAY	$ 610.00	$ -
16	**Water Treatment During Construction**					
17	Baker Tanks	Assume two 21,000-gallon Baker Tanks, for rental	90	DAY	$ 95.00	$ 8,550
18	Polymer	Use polymer to assist in particle settling	1	LS	$ 2,000.00	$ 2,000
19	Sediment Removal	Chemicals and Labor to remove sediments from baker tanks	1	LS	$ 5,000.00	$ 5,000
20	Bag Filter	1 Bag Filter, Barnaby-Seteliff BF 300, rental	3	MO	$ 250.00	$ 750
21	Bags	Assume new bag each day	90	EA	$ 10.00	$ 900
22	Carbon Filter	2 Single Vessel Carbon Filters Model LS360, rental	3	MO	$ 2,780.00	$ 8,340
23	Carbon	Carbon for Carbon Vessels	10,000	LB	$ 1.00	$ 10,000
24	Carbon Filter Disposal	Disposal of carbon filter after construction	10,000	LB	$ 0.10	$ 1,000
25	Freight	Cost from freighting equipment from and back to NV	2	LS	$ 2,500.00	$ 5,000
26	**Excavation of Trench behind Barrier Wall**	Assume disposed of as contaminated sediments	452	CCY	$ 18.60	$ 8,413
27	**Excavation of DNAPL Impacted Pond Materials**	Area of pond inside coffer dam assumed to be contaminated, 2.9' deep	2,964	CCY	$ 18.60	$ 55,139
28	**Stabilization Material**	Portland Cement	164	TON	$ 91.20	$ 14,951
29	**Stabilization of DNAPL Impacted Materials**	Mix Sediments and Trench Soil with Portland Cement in Pond	3,417	CCY	$ 7.69	$ 26,283
30	**Hauling Stabilized Trench Materials**	Load, haul bank run soil 2 mi, using front-end loader, load material and dump on to rail c	2,964	CCY	$ 6.44	$ 19,091
31	**Hauling Stabilized Pond Materials**	Load, haul bank run soil 2 mi, using front-end loader, load material and dump on to rail c	452	CCY	$ 6.44	$ 2,913
32	**Landfill Disposal of Stabilized Pond Materials**	Sediments disposed of in UPRR car to ECDC Environ. LF in East Carbon, UT	3,282	TON	$ 18.25	$ 59,890
33	**Landfill Disposal of Stabilized Trench Materials**	Sediments disposed of in UPRR car to ECDC Environ. LF in East Carbon, UT	751	TON	$ 18.25	$ 13,708
34	**Hauling of Stablized Materials**	Hauling of Stabilized Pond and Trench Materials in railcars	4,033	TON	$ 9.14	$ 36,859
35	**Soil Analytical Analysis**	TRPH, VOA, SVOA, TCLP Metals, BTEXN, TOX	2	LS	$ 855.00	$ 1,710
36	**Backfill of DNAPL Seeps**	Borrow, buy&ld at pit, haul 2 mi RT&sprd w/200 HP dozer, topsoil, weed free	300	CCY	$ 15.15	$ 4,545
37	**Restoration of Bank**					
38	Restoration of Pond Bank-Cobbles	Borrow, crsh stone, 3/4", ld at pit,haul 2 mi RT&sprd w/200 HP dozer	1,043	CCY	$ 24.00	$ 25,031
39	Restoration of Pond Bank-Gravel	Borrow, crsh stone, 3/4", ld at pit,haul 2 mi RT&sprd w/200 HP dozer	489	CCY	$ 24.00	$ 11,733
40	Backfill of Clean Stock-Piled Topsoil	Borrow from on-site stockpile and haul back to site	2,484	CCY	$ 4.56	$ 11,339
41	Restoration of Pond Bank-Top Soil	Borrow, buy&ld at pit, haul 2 mi RT&sprd w/200 HP dozer, topsoil, weed free-clean fill	413	CCY	$ 15.15	$ 6,256
42	Compaction of Bank Overburden	Compact soil	2,897	CCY	$ 0.91	$ 2,636
44	**Trench Pipe**	Piping, not including excavation or backfill, class 160, 6" diameter	440	LF	$ 9.65	$ 4,246
45	**Trench Backfill**	Borrow, crsh stone, 3/4", ld at pit,haul 2 mi RT&sprd w/200 HP dozer	452	CCY	$ 24.00	$ 10,856
46	**DNAPL Sumps**	CB or manholes, conc, precast, 4' ID, 6' deep	2	EA	$ 1,500.00	$ 3,000
47	**DNAPL Pumps**	Assume pneumatic or "ANCHOR" pump	0	EA	$ 5,000.00	$ -
48	**DNAPL Pump Controls**	Assume pump operates on timer	0	LS	$ 2,000.00	$ -
49	**DNAPL Piping**	2" carbon steel pipe, sch 40, welded, buried 36 inches	0	LF	$ 15.27	$ -
50	**DNAPL Storage Tank**	Tanks,st,double wall,abv grnd,w/sprts,mway,ftngs,no mat,ps,piping,2000gal	0	EA	$ 5,575.00	$ -
51	**Monitoring Wells**	2-in dia., 20' deep, 10' screen, 0.1 slot	3	EA	$ 3,000.00	$ 9,000
52	**Coffer Dam Removal**	Excavation	867	CCY	$ 5.00	$ 4,333
53	**Electrical Power Lines and Transformer**	Power supply to construction site	1	LS	$ 10,000.00	$ 10,000
54	**Landscaping**	Seeding, hydro or air seeding for lg areas, incl seed and fertilizer	1,347	SY	$ 0.32	$ 431
55	**Subtotal**					$ 430,292
56	Unscoped items	Allow 10 percent	10	PCT	$ 430,292	$ 43,000
57	**Subtotal**					$ 473,292
58	General Requirements (Mob, bonds, insur)	Allow 10 percent	10	PCT	$ 473,292	$ 47,300
59	**Contract cost**					$ 520,592
60	Contingency	Allow no contingency	-	PCT	$ 520,592	$ -
61	**Construction Cost**					$ 520,592
62	Design	Allow 10 percent	10	PCT	$ 520,592	$ 52,100
63	Permitting	Allow 10 percent	10	PCT	$ 520,592	$ 52,100
64	Construction Oversight	Allow 10 percent	10	PCT	$ 520,592	$ 52,100
65	**Total**					**$ 676,892**
66	**Total [illegible]nded to the nearest $10,000**					**$ 680,000**

	A	B	C	D	E	F
1	**UPRR Ogden, Utah Yard**					
2	**September 2004**					
3	**Alternative 4 - DUS/HPO**					
4						
5						
6	**Item**	**Basis**	**Quantity**	**Unit**	**Unit Price**	**Ext Amount**
7	Utility connections	Based on preliminary cost information	1	LS	$ 52,400.00	$ 52,400
8	Drilling and well installation	Based on preliminary cost information	1	LS	$ 3,069,050.00	$ 3,069,050
9	Well-head completion and instrumentation	Based on preliminary cost information	1	LS	$ 2,990,000.00	$ 2,990,000
10	Fabrication and mobilization of process equipment	Based on preliminary cost information	1	LS	$ 4,733,500.00	$ 4,733,500
11	On-site well field piping and construction	Based on preliminary cost information	1	LS	$ 2,343,200.00	$ 2,343,200
12	Steam and water softening system installation	Based on preliminary cost information	1	LS	$ 115,650.00	$ 115,650
13	Effluent treatment system installation	Based on preliminary cost information	1	LS	$ 292,500.00	$ 292,500
14	Demobilization and waste disposal	Based on preliminary cost information	1	LS	$ 2,218,950.00	$ 2,218,950
15	Reporting	Based on preliminary cost information	1	LS	$ 22,576.00	$ 22,576
16	System operation	Based on preliminary cost information	1	LS	$ 18,760,950.00	$ 18,760,950
17						
18	**Subtotal**					$ 34,598,776
19	Unscoped items	Allow 10 percent	10	PCT	$ 34,598,776	$ 3,459,900
20	**Subtotal**					$ 38,058,676
21	General Requirements (Mob, bonds, insur)	Based on preliminary cost information	1	LS	$ 78,480	$ 78,480
22	**Contract cost**					$ 38,137,156
23	Contingency	Allow 30 percent	30	PCT	$ 38,137,156	$ 11,441,100
24	**Construction Cost**					$ 49,578,256
25	Design and Construction Oversight	Based on preliminary cost information	1	LS	$ 89,999	$ 89,999
26	General Requirements (Mob, bonds, insur)	Based on preliminary cost information	1	LS	$ 78,480	$ 78,480
27	**Total**					$ 49,746,735
28	**Total Rounded to the nearest $10,000**					**$ 49,750,000**

	A	B	C	D	E	F
1	**UPRR Ogden, Utah Yard**					
2	**September 2004**					
3	**Alternative 5 - Sediment Excavation in Pond**					
4						
5						
6	**Item**	**Basis**	**Quantity**	**Unit**	**Unit Price**	**Ext Amount**
10	**Excavation of Clean Fill**					
11		Barrier Wall	7,268	SF	$ 26.00	$ 188,968
12		SW Barrier Wall Wing Ends	1,050	SF	$ 26.00	$ 27,300
13		NE Barrier Wall Wing Ends	2,145	SF	$ 26.00	$ 55,770
14	Excavation	Borrow topsoil from site and haul to on-site stockpile	2,484	CCY	$ 4.56	$ 11,339
15	**Coffer Dam**	350 ft long, 5 ft average height, 4:1 slopes, & key trench	1,750	SF	$ 18.60	$ 32,550
16	**Oil Control Boom**	Boom on downstream side of coffer dam	5	DAY	$ 500.00	$ 2,500
17	**Dewatering of Pond**	Dewatering, pumping 8 hr, 8 hrs attended, 6" centrifugal pump	4	DAY	$ 760.00	$ 3,040
18	**Dewatering During Construction**	Dewatering, pumping 8 hr, 8 hrs attended, 4" diaphragm pump	42	DAY	$ 610.00	$ 25,620
19	**Water Treatment During Construction**					
20	Baker Tanks	Assume two 21,000-gallon Baker Tanks, for rental	90	DAY	$ 95.00	$ 8,550
21	Polymer	Use polymer to assist in particle settling	1	LS	$ 2,000.00	$ 2,000
22	Sediment Removal	Chemicals and Labor to remove sediments from baker tanks	1	LS	$ 5,000.00	$ 5,000
23	Bag Filter	1 Bag Filter, Barnaby-Sutcliff BF 300, rental	3	MO	$ 250.00	$ 750
24	Bags	Assume new bag each day	90	EA	$ 10.00	$ 900
25	Carbon Filter	2 Single Vessel Carbon Filters Model LS360, rental	3	MO	$ 2,780.00	$ 8,340
26	Carbon	Carbon for Carbon Vessels	10,000	LB	$ 1.00	$ 10,000
27	*Carbon Filter Disposal*	*Disposal of carbon filter after construction*	10,000	LB	$ 0.10	$ 1,000
28	Freight	Cost from freighting equipment from and back to NV	2	LS	$ 2,500.00	$ 5,000
29	**Excavation of Trench behind Barrier Wall**	Assume disposed of as contaminated sediments	452	CCY	$ 18.60	$ 8,413
30	**Excavation of DNAPL Impacted Pond Materials**	Area of pond inside coffer dam assumed to be contaminated, 2.9' deep	2,964	CCY	$ 18.60	$ 55,139
31	**Stabilization Material**	Portland Cement	164	TON	$ 91.20	$ 14,951
32	***Stabilization of DNAPL Impacted Materials***	*Mix Sediments and Trench Soil with Portland Cement in Pond*	3,417	CCY	$ 7.69	$ 26,283
33	**Hauling Stabilized Trench Materials**	Load, haul bank run soil 2 mi, using front-end loader, load material and dump on to rail c	2,964	CCY	$ 6.44	$ 19,091
34	**Hauling Stabilized Pond Materials**	Load, haul bank run soil 2 mi, using front-end loader, load material and dump on to rail c	452	CCY	$ 6.44	$ 2,913
35	**Landfill Disposal of Stabilized Pond Materials**	Sediments disposed of in UPRR car to ECDC Environ. LF in East Carbon, UT	3,282	TON	$ 18.25	$ 59,890
36	**Landfill Disposal of Stabilized Trench Materials**	Sediments disposed of in UPRR car to ECDC Environ. LF in East Carbon, UT	751	TON	$ 18.25	$ 13,708
37	**Hauling of Stabilized Materials**	Hauling of Stabilized Pond and Trench Materials in railcars	4,033	TON	$ 9.14	$ 36,859
38	**Soil Analytical Analysis**	TRPH, VOA, SVOA, TCLP Metals, BTEXN, TOX	2	LS	$ 855.00	$ 1,710
39	**Backfill of DNAPL Seeps**	Borrow, buy&ld at pit, haul 2 mi RT&sprd w/200 HP dozer, topsoil, weed free	300	CCY	$ 15.15	$ 4,545
40	**Restoration of Bank**					
41	Restoration of Pond Bank-Cobbles	Borrow, crsh stone, 3/4", ld at pit,haul 2 mi RT&sprd w/200 HP dozer	1,043	CCY	$ 24.00	$ 25,031
42	Restoration of Pond Bank-Gravel	Borrow, crsh stone, 3/4", ld at pit,haul 2 mi RT&sprd w/200 HP dozer	489	CCY	$ 24.00	$ 11,733
43	Backfill of Clean Stock-Piled Topsoil	Borrow from on-site stockpile and haul back to site	2,484	CCY	$ 4.56	$ 11,339
44	Restoration of Pond Bank-Top Soil	Borrow, buy&ld at pit, haul 2 mi RT&sprd w/200 HP dozer, topsoil, weed free-clean fill	413	CCY	$ 15.15	$ 6,256
45	Compaction of Bank Overburden	Compact soil	2,897	CCY	$ 0.91	$ 2,636
47	**Trench Pipe**	Piping, not including excavation or backfill, class 160, 6" diameter	440	LF	$ 9.65	$ 4,246
48	**Trench Backfill**	Borrow, crsh stone, 3/4", ld at pit,haul 2 mi RT&sprd w/200 HP dozer	452	CCY	$ 24.00	$ 10,856
49	**DNAPL Sumps**	CB or manholes, conc, precast, 4' ID, 6' deep	2	EA	$ 1,500.00	$ 3,000
50	**DNAPL Pumps**	Assume pneumatic or "ANCHOR" pump	0	EA	$ 5,000.00	$ -
51	**DNAPL Pump Controls**	Assume pump operates on timer	0	LS	$ 2,000.00	$ -
52	**DNAPL Piping**	2" carbon steel pipe, sch 40, welded, buried 36 inches	0	LF	$ 15.27	$ -
53	**DNAPL Storage Tank**	Tanks,st,double wall,abv grnd,w/sprts,mway,ftngs,no mat,ps,piping,2000gal	0	EA	$ 5,575.00	$ -
54	**Monitoring Wells**	2-in dia., 20' deep, 10' screen, 0.1 slot	3	EA	$ 3,000.00	$ 9,000
55	**Coffer Dam Removal**	Excavation	867	CCY	$ 5.00	$ 4,333
56	**Electrical Power Lines and Transformer**	Power supply to construction site	1	LS	$ 10,000.00	$ 10,000
57	***Landscaping***	*Seeding, hydro or air seeding for lg areas, incl seed and fertilizer*	1,347	SY	$ 0.32	$ 431
58	**Subtotal**					$ 730,990
59	Unscoped items	Allow 10 percent	10	PCT	$ 730,990	$ 73,100
60	**Subtotal**					$ 804,090
61	General Requirements (Mob, bonds, insur)	Allow 10 percent	10	PCT	$ 804,090	$ 80,400
62	**Contract cost**					$ 884,490
63	Contingency	Allow no contingency	-	PCT	$ 884,490	$ -
64	**Construction Cost**					$ 884,490
65	Design	Allow 10 percent	10	PCT	$ 884,490	$ 88,400
66	Permitting	Allow 10 percent	10	PCT	$ 884,490	$ 88,400
67	Construction Oversight	Allow 10 percent	10	PCT	$ 884,490	$ 88,400
68	**Total**					$ 1,149,690
69	**Total Rounded to the nearest $10,000**					$ 1,150,000

	A	B	C	D	E	F
1	**UPRR Ogden, Utah Yard**					
2	**September 2004**					
3	**Alternative 5- DNAPL Recovery**					
4						
5						
6	**Item**	**Basis**	**Quantity**	**Unit**	**Unit Price**	**Ext Amount**
7	Recovery well installation	Completion of 3 additional recovery wells	3	EA	$ 6,000.00	$ 18,000
8	Injection well installation	Completion of 3 additional injection wells	3	EA	$ 6,000.00	$ 18,000
9	Observation well installation	Completion of 9 additional observation wells	9	EA	$ 1,111.11	$ 10,000
10						
11	**Subtotal**					$ 46,000
12	Unscoped Items	Allow 10 percent	10	PCT	$ 46,000	$ 4,600
13	**Contract cost**					$ 50,600
14	Contingency	Allow 10 percent	10	PCT	$ 50,600	$ 5,100
15	**Total**					$ 55,700
16	**Total Rounded to the nearest $10,000**					$ 60,000

	A	B	C	D	E	F
1	**UPRR Ogden, Utah Yard**					
2	**September 2004**					
3	**Alt 5 - Operation and Maintenance Costs**					
4						
5	**Item**	**Basis**	**Quantity**	**Unit**	**Unit Price**	**Ext Amount**
6	***Years 1 to 30 of MNA Total Present Worth***					
7	MNA Monitoring	Estimated Total Present Worth	1	LS	$ 500,000	**$ 500,000**
8	***Years 1 to 3 of DNAPL Recovery Present Worth***					
9	System up-grade, modifications, and maintenance	Over 3 year period	1	LS	$ 150,000.00	$ 150,000
10	System operation and monitoring	Over 3 year period	1	LS	$ 300,000.00	$ 300,000
11	**Subtotal**					**$ 450,000**
12						
13	***Years 1 to 30 of Operation***					
14	Monitoring of DNAPL Sumps	4 hrs per week	208	HR	$ 61	$ 12,688
20					**TOTAL**	**$ 12,688**
21						
22						
23			*Present Value at 7% over 30 years*			**$1,107,000**
24						
25	Assumptions:					
26	The level of effort to complete monitoring is consistent over time for 30 years.					

UPRR Ogden, Utah Yard
FS - September 2004
Comparison of Costs

Alternative	Total Cost	Time
Alternative 1: No Action	$ -	0
Alternative 2: Monitored Natural Attenuation	$ 550,000	0+30
Alternative 3: MNA + Focused Source Removal	$ 950,000	1+30
Alternative 4: Aggressive Source Removal w/ MNA (best case)	$ 3,310,000	1+3+2
Alternative 4: Aggressive Source Removal w/ MNA (reasonable worst case)	$ 5,360,000	1+10+30
Alternative 5: Sparging Wall	$ 2,360,000	0+30
Alternative 6: Aggressive Groundwater Treatment (best case)	$ 6,900,000	1+3+2
Alternative 6: Aggressive Groundwater Treatment (reasonable worst case)	$ 11,260,000	1+10+30

North and South Plume Monitored Natural Attenuation
Operation and Maintenance Costs

	A	B	C	D	E	F
1	**Cost Estimate - Alternative 2**					
2	**UPRR Ogden Rail Yard FS**					
3	**Sep-04**					
4	**North and South Plume MNA**					
5						
6	**Item**	**Basis**	**Quantity**	**Unit**	**Unit Price**	**Ext Amount**
7	**Annual Monitoring, Years 1-5**					
8	Work Planning	Workplans, Logistics, Mobilizaiton	1	ea	$ 6,900.00	$ 6,900
9	Semiannual Field Sampling	2 events, 4 days per event, 2 field staff	1	ea	$ 17,400.00	$ 17,400
10	Laboratory Analysis	20 wells VOCs per event, 10 wells geochemical every 2 yrs, Qcsamples	1	ea	$ 10,600.00	$ 10,600
11	Annual Reporting		1	ea	$ 10,200.00	$ 10,200
12					Subtotal	$ 45,100
13	Unscoped Items	Allow 10 percent	10	PCT	$ 45,100	$ 4,500
14	**Contract cost**					$ 49,600
15	Contingency	Allow 15 percent	15	PCT	$ 49,600	$ 7,400
16					**Total**	**$ 57,000**
17					**Present Value**	**$ 233,711**
18	**Annual Monitoring, Years 6-30**					
19	Work Planning	Workplan, Health & Safety Plan, Mobilizaiton	1	ea	$ 3,500.00	$ 3,500
20	Annual Field Sampling	1 event, 4 days/event, 2 field staff	1	ea	$ 8,700.00	$ 8,700
21	Laboratory Analysis	20 wells VOCs per event, 10 wells geochemical every 2 yrs, Qcsamples	1	ea	$ 5,300.00	$ 5,300
22	Annual Reporting	Assumed 0.5 * year 1-5 annual report	1	ea	$ 5,100.00	$ 5,100
23					Subtotal	$ 22,600
24	Unscoped items	Allow 10 percent	10	PCT	$ 22,600	$ 2,300
25	**Contract cost**					$ 24,900
26	Contingency	Allow 15 percent	15	PCT	$ 24,900	$ 3,700
27					**Total**	**$ 28,600**
28					**Present Value**	**$ 237,633**
29	**5 Year Periodic Costs**					
30	Five Year Review Report	Assumed 2.5 * year 1-5 annual report	1	ea	$ 25,500.00	$ 25,500
31					Subtotal	$ 25,500
32	Unscoped items	Allow 10 percent	10	PCT	$ 25,500	$ 2,600
33	**Contract cost**					$ 28,100
34	Contingency	Allow 15 percent	15	PCT	$ 28,100	$ 4,200
35					**Total**	**$ 32,300**
36					**Present Value**	**$ 69,697**
37	**10 Year Periodic Costs**					
38	Monitoring Well Drilling	Assume 2 wells per 10 years	2	ea	$ 3,000.00	$ 6,000
39	*Oversight & reporting*	*Installation oversight, well logs*	1	*ea*	$ 2,300.00	$ 2,300
40					Subtotal	$ 8,300
41	Unscoped items	Allow 10 percent	10	PCT	$ 8,300	$ 800
42	**Contract cost**					$ 9,100
43	Contingency	Allow 15 percent	15	PCT	$ 9,100	$ 1,400
44					**Total**	**$ 10,500**
45					**Present Value**	**$ 9,430**
46						
47		**Present Value at 7% over 30 years**				**$ 550,472**
48		***Total Rounded to the nearest $10,000***				**$ 550,000**
49						
50						

UPRR Ogden Rail Yard
Focused Source Removal Cost Breakdown

	A	B	C	D	E	F
1	**Cost Estimate**					
2	**UPRR Ogden Rail Yard FS**					
3	**Final FS - September 2004**					
4	**Alternative 3 - Focused Source Removal**					
5						
6	**Item**	**Basis**	**Quantity**	**Unit**	**Unit Price**	**Ext Amount**
7	**Sewer Sludge Cleaning and Disposal**					
8	Video Survey	Conducted after cleaning	1	LS	$ 5,600.00	$ 5,600
9	Clean and flush 6" PVC and steel lines	Per length of piping	2310	LF	$ 8.00	$ 18,480
10	Clean and flush 10" VCP lines	Per length of piping	2450	LF	$ 10.00	$ 24,500
11	Sludge analysis	TCLP, 1 sample per 10 CY of sludge	3	EA	$ 725.00	$ 2,175
12	Sludge disposal (including rolloff cost)	Assumes all sludge (30 CY) is hazardous, 1.3 Tons/CY	39	TN	$ 1,000.00	$ 39,000
13	Plugging and sealing	For lines remaining in place	1	LS	$ 8,500.00	$ 8,500
14	**Excavation and Removal of VCP Pipe**					
15	Excavation down to and below pipe	Based on trench 2450' x 2' x 6' deep	2,178	CY	$ 6.00	$ 13,067
16	Soil stockpile	Segregate clean overburden from "dirty" dirt	2,178	CY	$ 1.20	$ 2,613
17	Confirmation sampling	Assumes 1 sample per 200 CY	5	EA	$ 100.00	$ 500
18	Disposal and transportation costs	Assumes bottom 4' is disposed non-haz off-site, 1.3	1,887	TN	$ 31.00	$ 58,510
19	Import clean fill	Place and compact	1,452	CY	$ 15.00	$ 21,778
20						
21	**Subtotal**					$ 194,722
22	Unscoped items	Allow 30 percent	20	PCT	$ 194,722	$ 38,900
23	**Subtotal**					$ 233,622
24	General Requirements (Mob, bonds, insur)	Allow 10 percent	10	PCT	$ 233,622	$ 23,400
25	**Contract cost**					$ 257,022
26	Contingency	Allow 30 percent	30	PCT	$ 257,022	$ 77,100
27	**Construction Cost**					$ 334,122
28	Design	Allow 10 percent	10	PCT	$ 334,122	$ 33,400
29	Construction Oversight	Allow 10 percent	10	PCT	$ 334,122	$ 33,400
30	**Total**					**$ 400,922**
31	**Total Rounded to the nearest $10,000**					**$ 400,000**

UPRR Ogden Rail Yard
Present Value Capital and Operation and Maintenance
Costs for Source Area Sparging Systems

Cost Component	Module			Scaling Factor	
	Size	C_M	Total Number	0.6	
South Plume Capital	4 Ac	$420,000	1.5	$	535,678
System O&M	1 module	$240,000	1.5	$	306,102
			South Plume Subotal	$	842,000
North Plume Capital	2 Ac	$390,000	6	$	1,142,761
System O&M	1 Module	$240,000	6	$	703,237
			North Plume Subtotal	$	1,846,000
			Combined Sparging Capital Subtotal	$	1,680,000
			Combined Sparging O&M Subtotal	$	1,010,000
			MNA Sampling and Reporting	$	220,000
			Subtotal Cost	$	**2,910,000**

Notes:

$C_x = C_M \times (N_x)^{SF}, where$

C_x = System Cost for the Total Number of Modules ($)

C_M = System Cost for One Module ($)

N_x = Total Number of Modules

SF = Scaling Factor

System O&M costs are based on a total treatment time of 5 years.

UPRR Ogden Rail Yard
North Plume 2 Acre Air Sparging Module Cost Breakdown

	A	B	C	D	E	F
1	**Cost Estimate - Alternative 4**					
2	**UPRR Ogden Rail Yard FS**					
3	**Sep-04**					
4	**North Plume 2 Acre Source Zone Treatment System**					
5						
6	**Item**	**Basis**	**Quantity**	**Unit**	**Unit Price**	**Ext Amount**
7	**Monitoring, Sampling, Testing**					
8	Pilot Testing	To refine design;	1	LS	$ 10,000.00	$ 10,000
9	Air Monitoring at Startup	Develop/execute plan to evaluate/mitigate impacts	1	LS	$ 1,000.00	$ 1,000
10	System Startup and Testing	1 time cost	1	LS	$ 20,000.00	$ 20,000
11						
12	**IAS Drilling**					
13	Mobilization/Demobilization	For drilling rig and crew	1	LS	$ 1,954.00	$ 1,954
14	H Stem, 8" OD Borehole for 2" Well	50 wells at 20' deep	1,000	LF	$ 17.86	$ 17,860
15	2" Sch. 80 PVC Well Casing	50 wells at 16' deep	800	LF	$ 3.42	$ 2,736
16	2" Sch. 80 PVC Well Screen	50 wells at 2' each	100	LF	$ 15.35	$ 1,535
17	2" Screen Filter Pack	50 wells at 4' each	200	LF	$ 8.15	$ 1,630
18	2" Well Bentonite Seal	50 wells	50	EA	$ 29.76	$ 1,488
19	Well Development Equipment and Rental	50 wells	50	EA	$ 200.00	$ 10,000
20	55 gal. Drums for Cuttings and Water	Periodically disposed of on site	50	EA	$ 76.48	$ 3,824
21	2' by 2' by 3' Precast Concrete Vaults	Per each well	50	EA	$ 115.80	$ 5,790
22	Field Geologist	50 wells at 3 wells per day	17	DY	$ 600.00	$ 10,200
23						
24	**IAS Piping**					
25	1" HDPE headers, w/ solenoid valve for pulsing	1 header pipe 168 feet long, per 50 wells	1	LF	$ 750.00	$ 750
26	1" HDPE branches, w/ flow control valve and pressure gauge	1 branch per 5 wells	10	EA	$ 1,000.00	$ 10,000
27	Clear and Grub for trenching	Prepare for trenching	2	AC	$ 163.35	$ 327
28	Chain Trencher (2' deep)	Assume 10"x12" (deep) trench	128	CY	$ 1.91	$ 245
29	Move Trencher around site	Assume 1 move	1	EA	$ 330.72	$ 331
30	Pipe Trench Gravel Backfill	Assume 10"x12" (deep) trench	128	CY	$ 6.00	$ 768
31						
32	**SVE Piping**					
33	4" Schedule 80 PVC main header	1 header pipe 126 feet long, per 36 wells	1	EA	$ 215.00	$ 215
34	2" Schedule 80 PVC branches w/ flow control valve	1 branch per 5 wells	10	EA	$ 1,000.00	$ 10,000
35	Clear and Grub for trenching	Prepare for trenching	2	AC	$ 163.35	$ 327
36	Chain Trencher (5' deep)	Assume 5x1' trench	250	CY	$ 1.91	$ 479
37	Move Trencher around site	Assume 1 move per 2 acres	1	EA	$ 330.72	$ 331
38	Pipe Trench Gravel Backfill	Based on 250 CY per 2 acres	250	CY	$ 6.00	$ 1,500
39	Geotextile liner over backfill	2 feet wide x trench length	2,688	SF	$ 0.55	$ 1,478
40						
41	**Process Equipment**					
42	Blower Building	Assumes 1 blower per building	1	EA	$ 15,000.00	$ 15,000
43	Electrical Hook-Up and I&C	Assumes 1 control panel per building	1	EA	$ 7,500.00	$ 7,500
44	Compressed air flow meter	One per blower	1	EA	$ 500.00	$ 500
45	10 hp, 230V Rotary Vane Blower System	125 cfm and 12 psi; includes pressure gauges	1	EA	$ 7,750.00	$ 7,750
46	20 hp SVE system, w/ flow meter	250 scfm and 10" Hg vacuum	1	EA	$ 10,785.00	$ 10,785
47	Construction Labor	Assumes 5 man crew at 20 days for 10 hrs/day	500	Hours	$ 58.00	$ 29,000
48						
49	**Miscellaneous**					
50	OVA Rental	Assumes OVA to be used by Field Geologist	3	WK	$ 300.00	$ 900
51	Decontaminate Equipment	Assumes decon only needed after drilling all wells	1	DY	$ 195.11	$ 195
52	Equipment Shipping to Site	1 time cost	1	LS	$ 5,000.00	$ 5,000
53	Surveying and Site Layout	Layout well, piping, building locations, etc.	1	LS	$ 1,500.00	$ 1,500
54						
55	**Subtotal**					$ 192,896
56	Unscoped Items	Allow 10 percent	10	PCT	$ 192,896	$ 19,300
57	**Subtotal**					$ 212,196
58	General Requirements (Mob, bonds, Insur)	Allow 10 percent	10	PCT	$ 212,196	$ 21,200
59	**Contract cost**					$ 233,396
60	Contingency	Allow 30 percent	30	PCT	$ 233,396	$ 70,000
61	**Construction Cost**					$ 303,396
62	Design	Allow 10 percent	10	PCT	$ 303,396	$ 30,300
63	Permitting	Allow 10 percent	10	PCT	$ 303,396	$ 30,300
64	Construction Oversight	Allow 10 percent	10	PCT	$ 303,396	$ 30,300
65	**Total**					**$ 394,296**
66	**Total Rounded to the nearest $10,000**					**$ 390,000**

UPRR Ogden Rail Yard
South Plume 4-Acre Air Sparging Module Cost Breakdown

	A	B	C	D	E	F
1	**Cost Estimate- Alternative 4**					
2	**UPRR Ogden Rail Yard FS**					
3	**September, 2004**					
4	**South Plume 4 Acre Source Zone Treatment System**					
5						
6	**Item**	**Basis**	**Quantity**	**Unit**	**Unit Price**	**Ext Amount**
7	**Monitoring, Sampling, Testing**					
8	Pilot Testing	To refine design;	1	LS	$10,000.00	$ 10,000
9	Air Monitoring at Startup	Develop/execute plan to evaluate/mitigate impacts	1	LS	$ 1,000.00	$ 1,000
10	System Startup and Testing	1 time cost	1	LS	$20,000.00	$ 20,000
11						
12	**IAS Drilling**					
13	Mobilization/Demobilization	For drilling rig and crew	1	LS	$ 1,954.00	$ 1,954
14	H Stem, 8" OD Borehole for 2" Well	50 wells at 20' deep	1,000	LF	$ 17.86	$ 17,860
15	2" Sch. 80 PVC Well Casing	50 wells at 16' deep	800	LF	$ 3.42	$ 2,736
16	2" Sch. 80 PVC Well Screen	50 wells at 2' each	100	LF	$ 15.35	$ 1,535
17	2" Screen Filter Pack	50 wells at 4' each	200	LF	$ 8.15	$ 1,630
18	2" Well Bentonite Seal	50 wells	50	EA	$ 29.75	$ 1,488
19	Well Development Equipment and Rental	50 wells	50	EA	$ 200.00	$ 10,000
20	55 gal. Drums for Cuttings and Water	Periodically disposed of on site	50	EA	$ 76.48	$ 3,824
21	2' by 2' by 3' Precast Concrete Vaults	Per each well	50	EA	$ 115.80	$ 5,790
22	Field Geologist	50 wells at 3 wells per day	17	DY	$ 600.00	$ 10,200
23						
24	**IAS Piping**					
25	1" HDPE headers, w/ solenoid valve for pulsing	1 header pipe 240 feet long, per 50 wells	1	EA	$ 1,125.00	$ 1,125
26	1" HDPE branches, w/ flow control valve and pressure	1 branch per 5 wells	10	EA	$ 1,500.00	$ 15,000
27	Clear and Grub for trenching	Prepare for trenching	4	AC	$ 163.35	$ 653
28	Chain Trencher (1' deep)	Assume 10"x12" (deep) trench	81	CY	$ 1.91	$ 156
29	Move Trencher around site	Assume 1 move	1	EA	$ 330.72	$ 331
30	Pipe Trench Gravel Backfill	Assume 10"x12" (deep) trench	81	CY	$ 6.00	$ 489
31						
32	**SVE Piping**					
33	4" Schedule 80 PVC main header	1 header pipe 180 feet long, per 36 wells	1	EA	$ 322.50	$ 323
34	2" Schedule 80 PVC branches w/ flow control valve	1 branch per 5 wells	10	EA	$ 1,500.00	$ 15,000
35	Clear and Grub for trenching	Prepare for trenching	4	AC	$ 163.35	$ 653
36	Chain Trencher (5' deep)	Assume 5x1' trench	355	CY	$ 1.91	$ 679
37	Move Trencher around site	Assume 1 move per 4 acres	1	EA	$ 330.72	$ 331
38	Pipe Trench Gravel Backfill	Based on 355 CY per 4 acres	355	CY	$ 6.00	$ 2,130
39	Geotextile liner over backfill	2 feet wide x trench length	3,840	SF	$ 0.55	$ 2,112
40						
41	**Process Equipment**					
42	Blower Building	Assumes 1 blower per building	1	EA	$15,000.00	$ 15,000
43	Electrical Hook-Up and I&C	Assumes 1 control panel per building	1	EA	$ 7,500.00	$ 7,500
44	Compressed air flow meter	One per blower	1	EA	$ 500.00	$ 500
45	10 hp, 230V Rotary Vane Blower System	125 cfm and 12 psi; includes pressure gauges	1	EA	$ 7,750.00	$ 7,750
46	20 hp SVE system, w/ flow meter	250 scfm and 10" Hg vacuum	1	EA	$10,785.00	$ 10,785
47	Construction Labor	Assumes 5 man crew at 20 days for 10 hrs/day	500	Hours	$ 58.00	$ 29,000
48						
49	**Miscellaneous**					
50	OVA Rental	Assumes OVA to be used by Field Geologist	3	WK	$ 300.00	$ 900
51	Decontaminate Equipment	Assumes decon only needed after drilling all wells	1	DY	$ 195.11	$ 195
52	Equipment Shipping to Site	1 time cost	1	LS	$ 5,000.00	$ 5,000
53	Surveying and Site Layout	Layout well, piping, building locations, etc.	1	LS	$ 1,500.00	$ 1,500
54						
55	**Subtotal**					$ 205,129
56	Unscoped items	Allow 10 percent	10	PCT	$ 205,129	$ 20,500
57	**Subtotal**					$ 225,629
58	General Requirements (Mob, bonds, insur)	Allow 10 percent	10	PCT	$ 225,629	$ 22,600
59	**Contract cost**					$ 248,229
60	Contingency	Allow 30 percent	30	PCT	$ 248,229	$ 74,500
61	**Construction Cost**					$ 322,729
62	Design	Allow 10 percent	10	PCT	$ 322,729	$ 32,300
63	Permitting	Allow 10 percent	10	PCT	$ 322,729	$ 32,300
64	Construction Oversight	Allow 10 percent	10	PCT	$ 322,729	$ 32,300
65	**Total**					**$ 419,629**
66	**Total Rounded to the nearest $10,000**					**$ 420,000**
67						

North and South Plume Source Area Air Sparging
Operation and Maintenance Costs

	A	B	C	D	E	F
1	**Cost Estimate - Alternative 4**					
2	**UPRR Ogden Rail Yard FS**					
3	**September 2004**					
4	**Modular Source Zone Treatment System O&M Costs**					
5						
6	**Item**	**Basis**	**Quantity**	**Unit**	**Unit Price**	**Ext Amount**
7	***3 Years of Operation***					
8	**Electrical Utilities**					
9	Air Sparging Blower	Assumes 1 blower operating full time	65,300	kwh	$ 0.06	$ 3,918
10	SVE Blower	Assumes 1 blower operating full time	130,650	kwh	$ 0.06	$ 7,839
11	Misc. power	e.g. heating and lighting, instrumentation; assumes 10% of sparging and SVE en	19,595	kwh	$ 0.06	$ 1,176
12	**Maintenance**					
13	IAS Blower Replacement	Assume yearly blowers replacement costs are 10% of blower capital costs	1	YR	$ 775.00	$ 775
14	SVE Blower Replacement	Assume yearly blowers replacement costs are 10% of blower capital costs	1	YR	$ 1,078.50	$ 1,079
15	**Labor**					
16	Operator labor	Assumes 52 weeks at 1 day per week	52	Day	$ 450.00	$ 23,400
17	Management oversight and reporting	Assumes 2 hrs/week + 40 hr annual report	144	hour	$ 100.00	$ 14,400
18					**Subtotal**	**$ 52,586**
19	**Subtotal**					
20	Unscoped items	Allow 30 percent	30	PCT	$ 52,586	$ 15,800
21	**Contract cost**					$ 68,386
22	Contingency	Allow 35 percent	35	PCT	$ 68,386	$ 23,900
23					**Total**	**$ 92,286**
24						
25						
26		**Present Value at 7% over 3 years**				**$ 242,188**
27		Total Rounded to the nearest $10,000				$ 240,000
28						
29						

North and South Plume Monitored Natural Attenuation
Operation and Maintenance Costs

	A	B	C	D	E	F
1	**Cost Estimate - Alternative 4**					
2	**UPRR Ogden Rail Yard FS**					
3	**September 2004**					
4	**North and South Plume MNA, w/ source sparging**					
5						
6	**Item**	**Basis**	**Quantity**	**Unit**	**Unit Price**	**Ext Amount**
7	**Annual Monitoring, Years 1-5**					
8	Work Planning	Workplans, Logistics, Mobilizaiton	1	ea	$ 6,900.00	$ 6,900
9	Semiannual Field Sampling	2 events, 4 days per event, 2 field staff	1	ea	$ 17,400.00	$ 17,400
10	Laboratory Analysis	20 wells VOCs per event, 10 wells geochemical every 2 yrs, Qcsamples	1	ea	$ 9,800.00	$ 9,800
11	Annual Reporting		1	ea	$ 10,200.00	$ 10,200
12					Subtotal	$ 37,400
13	Unscoped items	Allow 10 percent	10	PCT	$ 37,400	$ 3,700
14	**Contract cost**					$ 41,100
15	Contingency	Allow 15 percent	15	PCT	$ 41,100	$ 6,200
16					**Total**	**$ 47,300**
17		**Present Value at 7% over 5 years**				**$ 193,939**
18	**5 Year Periodic Costs**					
19	Five Year Review Report	Assumed 2.5 * year 1-5 annual repor	1	ea	$ 25,500.00	$ 25,500
20					Subtotal	$ 25,500
21	Unscoped items	Allow 10 percent	10	PCT	$ 25,500	$ 2,600
22	**Contract cost**					$ 28,100
23	Contingency	Allow 15 percent	15	PCT	$ 28,100	$ 4,200
24					**Total**	**$ 32,300**
25		**Present Value at 7% over 5 years**				**$ 23,029**
26						
27		**Present Value at 7% over 5 years**				**$ 216,969**
28		Total Rounded to the nearest $10,000				**$ 220,000**
29						
30						

UPRR Ogden Rail Yard
Present Value Capital and Operation and Maintenance
Costs for Source Area Sparging Systems (Reasonble Worst Case)
Alternative 4

Cost Component	Module Size	Module C_M	Module Total Number	Scaling Factor 0.6
South Plume Capital	4 Ac	$420,000	1.5	$ 535,678
System O&M	1 module	$650,000	1.5	$ 829,026
			South Plume Subotal	$ 1,365,000
North Plume Capital	2 Ac	$390,000	6	$ 1,142,761
System O&M	1 Module	$650,000	6	$ 1,904,601
			North Plume Subtotal	$ 3,047,000
			Combined Sparging Capital Subtotal	$ 1,680,000
			Combined Sparging O&M Subtotal	$ 2,730,000
			MNA Sampling and Reporting	$ 550,000
			Subtotal Cost	**$ 4,960,000**

Notes:

$$C_x = C_M \times (N_x)^{SF}, where$$

C_x = System Cost for the Total Number of Modules ($)

C_M = System Cost for One Module ($)

N_x = Total Number of Modules

SF = Scaling Factor

System O&M costs are based on a total treatment time of 10 years.

North and South Plume Source Area Air Sparging
Operation and Maintenance Costs (Reasonable Worst Case)

	A	B	C	D	E	F
1	**Cost Estimate - Alternative 4**					
2	**UPRR Ogden Rail Yard FS**					
3	**September 2004**					
4	**Modular Source Zone Treatment System O&M Costs**					
5						
6	**Item**	**Basis**	**Quantity**	**Unit**	**Unit Price**	**Ext Amount**
7	***5 Years of Operation***					
8	**Electrical Utilities**					
9	Air Sparging Blower	Assumes 1 blower operating full time	65,300	kwh	$ 0.06	$ 3,918
10	SVE Blower	Assumes 1 blower operating full time	130,650	kwh	$ 0.06	$ 7,839
11	Misc. power	*e.g. heating and lighting, instrumentation; assumes 10% of sparging and SVE en*	19,595	kwh	$ 0.06	$ 1,176
12	**Maintenance**					
13	IAS Blower Replacement	Assume yearly blowers replacement costs are 10% of blower capital costs	1	YR	$ 775.00	$ 775
14	SVE Blower Replacement	Assume yearly blowers replacement costs are 10% of blower capital costs	1	YR	$ 1,078.50	$ 1,079
15	**Labor**					
16	Operator labor	Assumes 52 weeks at 1 day per week	52	Day	$ 450.00	$ 23,400
17	Management oversight and reporting	Assumes 2 hrs/week + 40 hr annual report	144	hour	$ 100.00	$ 14,400
18					**Subtotal**	**$ 52,586**
19	**Subtotal**					
20	Unscoped items	Allow 30 percent	30	PCT	$ 52,586	$ 15,800
21	**Contract cost**					$ 68,386
22	Contingency	Allow 35 percent	35	PCT	$ 68,386	$ 23,900
23					**Total**	**$ 92,286**
24						
25						
26		**Present Value at 7% over 10 years**				**$ 648,180**
27		Total Rounded to the nearest $10,000				**$ 650,000**
28						
29						

UPRR Ogden Rail Yard
North Plume Air Sparging Barrier Wall
Capital Cost Breakdown

	A	B	C	D	E	F
1	**Cost Estimate-Alternative 5**					
2	**UPRR Ogden Rail Yard FS**					
3	**September 2004**					
4	**North Plume Barrier Wall Treatment System**					
5						
6	**Item**	**Basis**	**Quantity**	**Unit**	**Unit Price**	**Ext Amount**
7	**Monitoring, Sampling, Testing**					
8	Pilot Testing	To refine design;	1	LS	$ 20,000.00	$ 20,000
9	System Startup and Testing	1 time cost	1	LS	$ 20,000.00	$ 20,000
10						
11	**Drilling**					
12	Mobilization/Demobilization	For drilling rig and crew	1	LS	$ 1,954.00	$ 1,954
13	H Stem, 8" OD Borehole for 2" Well	85 wells at 17' deep	1,445	LF	$ 17.86	$ 25,808
14	2" Sch. 80 PVC Well Casing	85 wells at 14' deep	1,190	LF	$ 3.42	$ 4,070
15	2" Sch. 80 PVC Well Screen	85 wells at 2' each	170	LF	$ 15.35	$ 2,610
16	2" Screen Filter Pack	85 wells at 4' each	340	LF	$ 8.15	$ 2,771
17	2" Well Bentonite Seal	85 wells	85	EA	$ 29.75	$ 2,529
18	Well Development Equipment and Rental	85 wells	85	EA	$ 200.00	$ 17,000
19	55 gal. Drums for Cuttings and Water	Periodically disposed of on site	85	EA	$ 76.48	$ 6,501
20	2' by 2' by 3' Precast Concrete Vaults	Per each well	85	EA	$ 115.80	$ 9,843
21	Field Geologist	85 wells at 4 wells per day	21	DY	$ 580.00	$ 12,325
22						
23	**Piping**					
24	1" HDPE header pipe	16 feet seperating each row, w/ solenoid valves for pulsing	64	LF	$ 8.00	$ 512
25	1" HDPE branches	2 rows per wall, from building to end of manifold	2,500	LF	$ 6.00	$ 15,000
26	Clear and Grub for trenching	Prepare for trenching	1.5	AC	$ 163.35	$ 245
27	Chain Trencher (1' deep)	Assumes 1' deep x 10" wide trench	78	CY	$ 1.91	$ 149
28	Move Trencher around site	Assume 1 move per wall	2	EA	$ 330.72	$ 661
29	Pipe Trench Gravel Backfill	Assumes 1' deep x 10" wide trench	78	CY	$ 22.55	$ 1,759
30						
31	**Process Equipment**					
32	Blower Building	Assumes 1 blower per building	2	EA	$ 15,000.00	$ 30,000
33	Electrical Hook-Up and I&C	Assumes 1 control panel per building	2	EA	$ 7,500.00	$ 15,000
34	Compressed air flow meter	One per blower	2	EA	$ 500.00	$ 1,000
35	10 hp, 230V Rotary Vane Blower System	125 cfm and 15 psi; includes pressure gauges	2	EA	$ 7,750.00	$ 15,500
36	Construction Labor	Assumes 5 people at 30 days for 10 hrs/day	1,500	Hours	$ 58.00	$ 87,000
37						
38	**Miscellaneous**					
39	OVA Rental	Assumes OVA to be used by Field Geologist	8	WK	$ 300.00	$ 2,400
40	Decontaminate Equipment	Assumes decon only needed after drilling all wells	1	DY	$ 195.11	$ 195
41	Equipment Shipping to Site	1 time cost	1	LS	$ 5,000.00	$ 5,000
42	Site Security Fence	Perimeter around treatment area	3000	LF	$ 27.77	$ 83,310
43	Surveying and Site Layout	Layout well, piping, building locations, etc.	1	LS	$ 1,500.00	$ 1,500
44						
45	**Subtotal**					$ 384,641
46	Unscoped items	Allow 10 percent	10	PCT	$ 384,641	$ 38,500
47	**Subtotal**					$ 423,141
48	General Requirements (Mob, bonds, insur)	Allow 10 percent	10	PCT	$ 423,141	$ 42,300
49	**Contract cost**					$ 465,441
50	Contingency	Allow 30 percent	30	PCT	$ 465,441	$ 139,600
51	**Construction Cost**					$ 605,041
52	Design	Allow 10 percent	10	PCT	$ 605,041	$ 60,500
53	Permitting	Allow 10 percent	10	PCT	$ 605,041	$ 60,500
54	Construction Oversight	Allow 10 percent	10	PCT	$ 605,041	$ 60,500
55	**Total**					$ 786,541
56	**Total Rounded to the nearest $10,000**					$ 790,000

	A	B	C	D	E	F
1	**Cost Estimate - Alternative 5**					
2	**UPRR Ogden Rail Yard FS**					
3	**September 2004**					
4	**North Plume Barrier Wall Treatment System**					
5						
6	**Item**	**Basis**	**Quantity**	**Unit**	**Unit Price**	**Ext Amount**
7	***30 Years of Operation***					
8	**Electrical Utilities**					
9	Air Sparging Blower	Assumes 2 10 hp blowers operating full time	130,600	kwh	$ 0.06	$ 7,836
10	Misc. power	*e.g control panels, heating and lighting; assumes 10% of sparging energy*	13,060	kwh	$ 0.06	$ 784
11	**Maintenance**					
12	Blower Replacement	Assume yearly blowers replacement costs are 10% of blower capital costs	2	YR	$ 200.00	$ 400
13	**Labor**					
14	Operator labor	Assumes 52 weeks at 1 day per week	52	Day	$ 450.00	$ 23,400
15	Management oversight and reporting	Assumes 2 hrs/week + 40 hr annual report	144	hour	$ 100.00	$ 14,400
16					**Subtotal**	**$ 46,820**
17	**Subtotal**					
18	Unscoped items	Allow 30 percent	30	PCT	$ 46,820	$ 14,000
19	**Contract cost**					$ 60,820
20	Contingency	Allow 35 percent	35	PCT	$ 60,820	$ 21,300
21					**Total**	**$ 82,120**
22						
23						
24		**Present Value at 7% over 30 years**				**$ 1,019,025**
25		**Present Value Rounded to the nearest $10,000**				**$ 1,020,000**
26						

UPRR Ogden Rail Yard
Present Value Capital and Operation and Maintenance
Costs for Alternative 6 Sparging Systems

Cost Component	Module Size	Module C_M	Module Total Number	Scaling Factor 0.6
South Plume Capital	4 Ac	$420,000	6	$ 1,230,666
System O&M	1 module	$240,000	6	$ 703,237
			South Plume Subotal	$ 1,934,000
North Plume Capital	2 Ac	$390,000	25	$ 2,690,473
System O&M	1 Module	$240,000	25	$ 1,655,676
			North Plume Subtotal	$ 4,346,000
			Sparging Capital Combined Subtotals	$ 3,920,000
			Sparging O&M Combined Subtotals	$ 2,360,000
			Sampling and Reporting	$ 220,000
			Subtotal Cost	$ **6,500,000**

Notes:

$C_x = C_M \times (N_x)^{SF}$, *where*

C_x = System Cost for the Total Number of Modules ($)

C_M = System Cost for One Module ($)

N_x = Total Number of Modules

SF = Scaling Factor

UPRR Ogden Rail Yard
Present Value Capital and Operation and Maintenance
Costs for Source Area Sparging Systems (Reasonble Worst Case)
Alternative 6

	Module			Scaling Factor
Cost Component	**Size**	**C_M**	**Total Number**	**0.6**
South Plume Capital	4 Ac	$420,000	6	$ 1,230,666
System O&M	1 module	$650,000	6	$ 1,904,601
			South Plume Subotal	$ 3,135,000
North Plume Capital	2 Ac	$390,000	25	$ 2,690,473
System O&M	1 Module	$650,000	25	$ 4,484,121
			North Plume Subtotal	$ 7,175,000
			Combined Sparging Capital Subtotal	$ 3,920,000
			Combined Sparging O&M Subtotal	$ 6,390,000
			MNA Sampling and Reporting	$ 550,000
			Subtotal Cost	**$ 10,860,000**

Notes:

$$C_x = C_M \times (N_x)^{SF}, where$$

C_x = System Cost for the Total Number of Modules ($)

C_M = System Cost for One Module ($)

N_x = Total Number of Modules

SF = Scaling Factor

System O&M costs are based on a total treatment time of 10 years.

APPENDIX I
VISALIA POLE YARD SITE SYNOPSIS

MEMORANDUM

THE FORRESTER GROUP
INSIGHTFUL ENVIRONMENTAL SOLUTIONS℠

Date: June 18, 2004

To: Hoyt Sutphin

From: Rob Jackson

Subject: Appendix Referencing the Visalia, CA Site

Copy to: Jay Hoskins

Project Number: 306

Southern California Edison Company Visalia Pole Yard NPL, Visalia, California

The purpose of this memorandum is to provide a brief synopsis of the Visalia Pole Yard NPL site and the DUS/HPO remediation system used there. A more comprehensive summary of this subject is available in Attachment 1.

Site Background:

The Visalia Pole Yard is a 4 acre site located about 50 miles Southeast of Fresno, CA. The site was used by The Southern California Edison Company (SEC) to conduct operations of a wood treating plant from 1925 to 1980. Impacted soil and groundwater by creosote, pentachlorophenol (PCP), and diesel fuel led to the designation as a Superfund site in 1975. The chemicals of concern (relic wood treating wastes) are a variety of polycyclic aromatic hydrocarbons (PAHs), PCP, and dioxins.

The constituents of concern are detected in groundwater 75-105 feet below ground surface. The source of groundwater impacts includes dense non-aqueous phase liquid (DNAPL). The site geology generally consists of a mixture of sands, silts, and cobbles.

Beginning in May 1994, in situ steam enhanced injection and extraction, with supplemental air injection to enhance in-situ chemical and metabolic oxidation, was utilized to remove the source of groundwater impacts, including DNAPL. This thermal treatment process is also known as Dynamic Underground Stripping with Hydrous Pyrolysis Oxidation (DUS/HPO). A remedial goal of this project was to reduce site groundwater concentrations of pentachlorophenol, benzo(a)pyrene, and Tetrachlorodibenzo-p-Dioxin$_{eqv}$ to MCLs (1 μg/L, 0.2 μg/L, and 30 ?g/L, respectively).

DUS System Technology:

At the Visalia site, steam and air were injected to a depth of 80-100 feet in paired wells, building a heated, oxygenated zone in which contaminated groundwater mixes with steam and oxygen. The system consisted of 11 injection wells, 7 liquid/vapor extraction wells, 4 steam boilers, a vacuum system, a two-staged heat exchange system, vapor treatment system, and a tertiary water treatment system. Electrical resistance tomography (ERT) and thermocouples were used to model the subsurface heated zone and evaluate treatment effectiveness.

At capacity, the system could deliver 200,000 pounds per hour of steam to the 11 injection wells. However the system was operated at 80,000 to 120,000 pounds per hour to maintain hydraulic control of the plume. The vapor and liquid phases were captured and treated. Vapors were treated in a steam boiler via oxidization. Liquid phase contaminants were sent through a tertiary treatment process, including an air flotation system which removed suspended particles and colloids by suspending and skimming them at the surface. Remaining liquids were then treated in a series of filtration processes and granulated activated carbon columns. The effluent was discharged to the sewer under an industrial waste discharge permit.

The DUS system injected a total of 660 million pounds of steam into the subsurface from May 1997 to June 2000, and removed 1.33 million pounds of wood preservative chemicals. Remedial efforts ended in March 2004. The cost of the project has totaled approximately $25,000,000 over the ten year life span of the project.

Effectiveness

The DUS/HPO system was effective at removing DNAPL and reducing aqueous phase concentrations at the Visalia site. However, in the source zone, dioxins and benzo(a)pyrene remain at concentrations above MCLs. Therefore, future land use will be limited through institutional controls, and monitoring at the facility boundary is expected to be ongoing at the site. A pump and treat system, including a water treatment plant, continues to be operated as a contingency measure.

An additional effect of steam injection was that DNAPL and impacted groundwater were smeared through the subsurface. Since steam injection operations have ended, the groundwater plume appears to be at steady-state.

Requests for site closure have been submitted, and a decision will be made pending compliance with groundwater standards at the facility boundary.

References

Dynamic Underground Stripping with Hydrous Pyrolysis Oxidation (DUS/HPO) - In-Situ Destruction of DNAPLs and Dissolved Contaminants in Groundwater, ESTCP
http://www.estcp.org/projects/cleanup/200014o.cfm

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Innovative Technology Summary Report, Hydrous Pyrolysis Oxidation/Dynamic Underground Stripping, USDOE, February 2000 (DOE/EM-0504).

Groundwater Currents, Dynamic Underground Stripping for Creosote Removal, USEPA, June 1998 (EPA 542-N-98-006).

MEMORANDUM

THE FORRESTER GROUP
INSIGHTFUL ENVIRONMENTAL SOLUTIONS℠

ATTACHMENT 1

Site: Southern California Edison Company
Visalia Pole Yard NPL site, Visalia, California

Contaminants: Polycyclic Aromatic Hydrocarbons (creosote), Diesel, Pentachlorophenol, Polychlorinated Dibenzo-p-Dioxins, and Polychlorinated Dibenzo-p-furans

Technology: In Situ Steam Enhanced Extraction with Supplemental Air Injection to Enhance In-Situ Chemical and Metabolic Oxidation

History: The Southern California Edison Company operated a wood treating plant from 1925 to 1980 during which the subsurface soil and groundwater were infiltrated, to a depth of 120 ft. with polycyclic aromatic hydrocarbons (PAHs), pentachlorophenol (PCP), polychlorinated dibenzo-p-dioxins, polychlorinated dibenzo-p-furans ($TCDD_{eqv}$), and diesel (wood preservative chemicals). Since 1975, Edison has pumped and subsequently treated approximately 2.5 billion gallons of groundwater to control gradient and minimize plume volume of these dense non-aqueous phase liquids (DNAPLs) and the dissolved constituents.

Project Goals: The general project objective was to remove the source of contamination from the subsurface and allow "natural attenuation" to degrade the remaining aqueous-phase plume. Specific goals are listed in the following table.

Visalia Steam Remediation Project Groundwater Remediation Standards	
Parameter	Concentration
Pentachlorophenol	1 μg/L
Benzo(α)Pyrene	0.2 μg/L
Tetrachlorodibenzo-p-$Dioxin_{eqv}$	30 ρg/L

Engineered Systems SCE started with 11 steam injection wells, 7 liquid/vapor extraction wells, 4 steam boilers, a vacuum system, a two-staged heat exchange system, vapor treatment system, and a tertiary water treatment system. Electrical Resistance Tomography (ERT) and thermocouples were deployed via 29 wells to image the subsurface heated zone.

The steam generation system could deliver a maximum of 200,000 pound per hour, with nominal injection rates of 80,000 to 120,000 pound per hour. Recovery wells and treatment systems were capable of removing approximately 140,000 lbs (H_2O/min.), maintaining overall hydraulic control of the site at nominal injection rates. Recovered liquids (groundwater and condensate) and vapors were separated and pumped to respective treatment systems. The noncondensable gases (vapors) were piped to the steam generators and thermally destroyed in the fire-box of the boiler. Groundwater and condensate were pumped to head-works of the tertiary water treatment system. This system consisted of serial separation (gravity and air-flotation), parallel dual media and polish filtration, and serial treatment by granular activated carbon. The treated effluent was discharge to the local sewer under an industrial waste discharge permit.

Major Design Parameters and Specifications	
Well Field Dimensions	145 ft. by 2 acres
Contaminated Material Volume	375,000 yd^3
Heated Material Volume	>1,000,000 yd^3
Water Treatment Plant Capacity	400 gpm
Vapor Extraction System Capacity	2500 scfm
Steam Injection System	120,000 lbs/hr (+ 80% Reserve)

Preliminary Results: During May 1997 to June 2000, approximately 660 million pounds of steam were injected into the subsurface formation. Approximately 1.33 million pounds of wood preservative chemicals in the formation were mobilized and removed/destroyed. The following table depicts the wood treating chemical mass removed by free, aqueous, or vapor phase, and by chemical oxidation.

Removed Mass by Phase Category		
Phase	**Mass Removed (lbs)**	**% Removed of Total**
Free	678,300	51
Vapor	239,400	18
In-situ Oxidation	212,800	16
Aqueous	199,500	15
Total	**1,330,000**	100

Southern California Edison designed and built a "carbon tracking" system which on a real-time basis accounted for the mass removed in the aqueous and vapor phases. Oxidation in place was determined from the increase in CO_2 and dissolved carbonate over the native groundwater and injected steam, taking temperature/solubility relationships into account. Free-phase wood treating chemicals were measured daily from the skimmed volumes emanating from the gravity separators.

Operational Considerations: The system components must be robust and have inherent flexibility to maintain operational integrity. Strength and material compatibility if not addressed properly will result in many unforeseen events ranging from significant project delays to catastrophic failures. The Visalia design was robustly designed, constructed and maintained 96 percent operational capacity factor during 36 months of steaming operations.

The initial target of steam injection focused on the intermediate aquitard, which is a heterogeneous saturated zone typified by inter-bedded coarse sand and cobble sized material. This aquitard is about 80 feet to 100 feet below the ground level (bgl). The steam injection wells were installed in a circular array around the contaminant mass. The steam was injected to mobilize the wood preservative chemicals to centrally located liquid and vapor extraction wells. This operation scheme was a classic "steam flood" of the intermediated aquitard which relies on the integrity of the confining formations (shallow and intermediate aquitards) to drive the "steam chest" horizontally across the intermediate aquifer. Under this scenario, the aquifer is primarily heated by convection. Portions of the confining shallow and intermediate aquitards would be conductively heat. Heat transfer modeling indicated that the first 15 feet of the intermediate aquitard would achieve the desired thermal treatment threshold of 100 oC if the leading surface of this confining layer were exposed to steam temperatures for 140 days.

This operational mode continued for approximately 10 months. The recovery rates of contaminants ranged from 2000 pounds to a record high of about 14,000 pounds in one day. The subsurface thermal signature resembled a "donut-shaped" plume of elevated temperatures approaching the apparent formation boiling point of water.

The original design called for three of the extraction wells to be adapted to inject steam. The second phase of steam injection, which was still based on aquifer steamflood, was initiated to inject steam in the center of the contaminant mass. The electrical resistance tomography proved to be a valuable tool in managing the duration of steam injection from the center of the contaminant mass. The treatment of the intermediate aquitard based on steam flood techniques continued for an additional 8 months. The typical formation heat signature indicated temperatures approaching the apparent water boiling point from about 95 feet bgl virtually to the surface.

Steam flood techniques were not fully successful at conductively heating the intermediate aquitard. This method suffered from the persistent problem of "steam over-ride" which has been well documented by the enhanced oil recovery industry. There were two additional factors which added a cooling effect in the lower reaches of the intermediate aquifer. The material at 95 feet bgl is described as a 5 foot deposition of cobble size material with an estimated horizontal groundwater velocity of greater than 3 feet per day. The second factor was a vertical connectivity of the "deep aquifer" into the intermediated aquifer. The vertical flux rate was measured at approximately 3 gallons per day per square foot. The introduction of native groundwater at ambient temperature (~16 °C) both laterally and vertically imparted sufficient cooling capacity to prevent the desired heating of this part of the formation.

An alternative method relying on injecting steam below the intermediate aquitard was conceived and subsequently approved by the DTSC. This aquitard is about 100 feet to 125 feet bgl and is characterized as inter-bedding of sand, fine sand, and silts. This aquitard had been shown, during the 1991 Remedial Investigation, to have been significantly penetrated with the wood treating chemicals. It was also obvious that the intermediate aquitard was not impervious to permeation, based on the stated flux rates from the deep water bearing unit into the intermediate aquifer.

Three injection wells were drilled into the "deep" aquifer to a depth of 145 feet bgl. Heating the intermediate aquitard from below employed the natural physical character of the "buoyancy" of steam. Steam injected below this aquitard would take the "path of least resistance" and travel to the bottom edge of this formation and propagate in a radial fashion across the bottom of the aquitard. The steam would also take the same pathways through this aquitard that the native groundwater utilized in the vertical accent from the deeper unit into the intermediate aquifer. As the steam ascended, the contaminant mass was mobilized ahead of the steam front and delivered to the extraction wells in the intermediate formation. Steam injection cycles were virtually continuous to uniformly heat the intermediate aquitard and provide a thermal barrier for downward migration of the chemicals of concern. Additional extraction wells were installed into the deep aquifer as a precautionary measure.

An additional phenomenon was observed at Visalia that greatly reduced the possibility of downward migration of the wood treating chemicals. The specific gravity of the mixture of wood treating chemicals was measured at 1.11. Thus the free-phase mass within the formation was considered to be a DNAPL. . The first 3500 gallons of recovered product resembled the original mixture, in terms of color, odor, and density. When the wood treating chemicals were exposed to temperatures in excess of 50 °C, and most probably in the presence of water, there was a dramatic change in the physical and chemical characters of this mixture. The original mixture was black in color and had a distinct coal-tar odor.

After the thermal soak, the extracted mass, changed in appearance to a tight gray emulsion while retaining a coal-tar odor, albeit reduced in intensity. Of primary importance, the density of the recovered mass was lighter than water. Assays performed at LLNL indicate that the mixture of wood treating chemical was saponified, essentially changing a DNAPL into a Light Non-Aqueous Phase Liquid (LNAPL).

Injecting steam into the "deep" aquifer continued for 18 months with approximately an additional 440,000 pounds of wood treating chemical recovered from the intermediate aquitard.

Groundwater Quality: Pentachlorophenol was considered as the target compound to be removed in the source area considering that it was the most soluble chemical in the suite of wood preservative chemicals use at the Visalia facility. Historically, PCP was detected in monitoring wells located about 1000 yards from the VPY western property boundary. Through an aggressive pumping program from 1975 to 1990, the PCP aqueous phase plume was reduced to area roughly within the property boundary (refer Figure 1).

The Visalia pump and treat program prior to steam injection was beneficial in preventing and reducing the down-gradient migration of the more soluble hydrocarbons such as PCP and naphthalenes. The pump and treat system operated to control the spread of contamination; however this technology would never achieve regulatory compliance within a manageable timeframe. SCE, after a significant selection process, elected to implement a thermal remedy to eliminate the cause of the impact to the groundwater. The Visalia in situ thermal remedy has attained a measurable improvement in groundwater quality at the facility.

The following graphs (1-6) describe the groundwater quality for the parameters listed in the above table. Graphs 1-3 present the analytical results in groundwater extracted from a well in the vicinity of the "point of compliance". Graphs 4-6 present similar groundwater assays from a production well in former free-phase hydrocarbon plume (source area). In general, the graphs for PCP and B(a)P contain approximately 150 data points, and, the $TCDD_{eqv}$ graphs contain about 20 data points. The data comprehensively describes the trend of improving groundwater quality from the initiation of steam injection to the present. Similar data sets exist for 12 additional production wells, all of which, exhibit similar trends. The data selected for this report is representative of the improving groundwater quality at the Visalia Pole Yard.

The groundwater extracted from EW-4 has shown two orders of PCP mass reduction since May 1997 which was the on-set of steam injection activities. The May 2003 PCP assay is lower than the Remediation Standard of 1 ug/L. This trend is encouraging; however, the data may not be entirely representative in light of that these results are from an extraction well.

The B(a)P and dioxins data indicate that these parameters do not adversely impact the groundwater in the vicinity of the "compliance point". During three years of active steam injection cycles and the subsequent three years of post-steaming activities, these organic chemical species have not been detected at concentrations which exceed the Remediation Standards.

In reviewing the quality of the groundwater pumped from the "source area" (Refer Graphs 4, 5, & 6), it becomes evident there was a considerable mobilization of PCP, B(a)P, and Dioxins occurred during steam injection cycles.

The highest recorded initial PCP concentration (1300 ug/L) in the groundwater has been reduced to a concentration below the method detection limit (ND @ < 1 ug/L). Since, December 2000, there has been one time period, in which, the level of PCP in the groundwater was assayed in concentrations above the Remediation Standard. During this event (~ Dec. 2000), a cluster of assays recorded concentrations above the detection limit, however, only two the results were recorded above the remediation standard (1.3 ug/L and 2.1 ug/L, respectively). Since December 12, 2001 all assays results were reported at concentrations below the regulatory limit (1.0 ug/L). The two data points above the detection limit in early 2003 were measured at concentrations about 0.7 ug/L.

Pumping of S-14i still produces groundwater with B(a)P concentrations in excess of the regulatory limit of 0.2 ug/L. However, looking at the body of this data it becomes clear that thermal treatment of the groundwater matrix in the vicinity of S-14 has resulted in a measurable improvement in quality in term of B(a)P. The B(a)P concentration has steady decreased from a maximum of 880 ug/L to 2 ug/L.

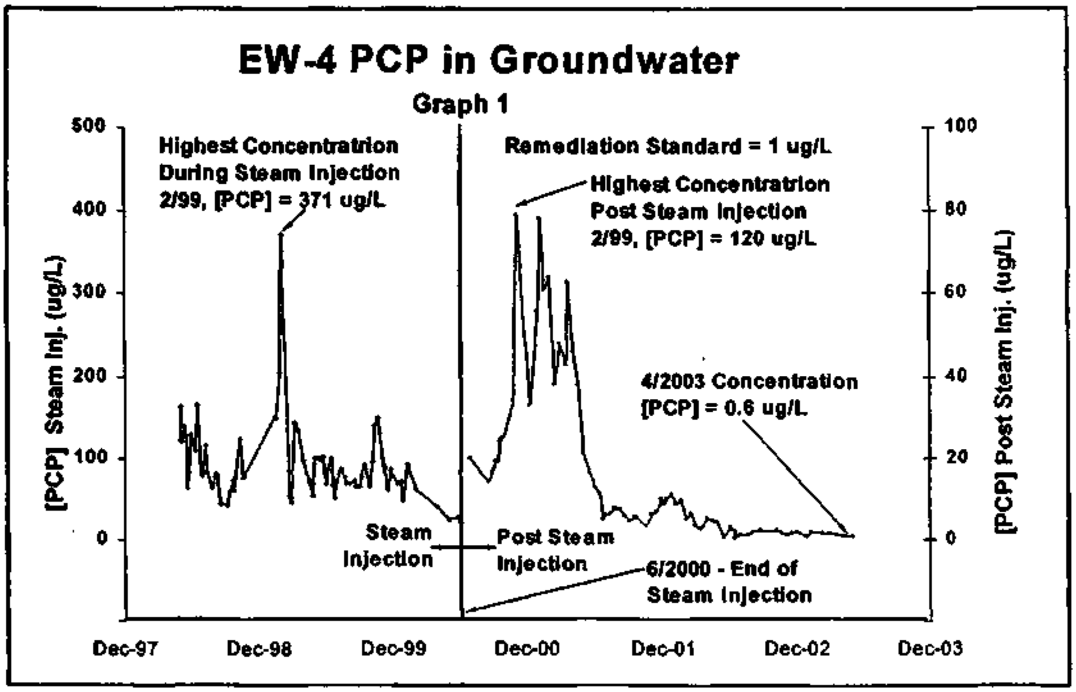
The same conclusion drawn for B(a)P concentrations in S-14i can be made for the Dioxins concentrations represented in Graph 6. The highest dioxin concentration was measured in excess of 160,000 pg/l. The groundwater dioxin content has progressively reduced in mass to the current measured amount of 280 pg/L.

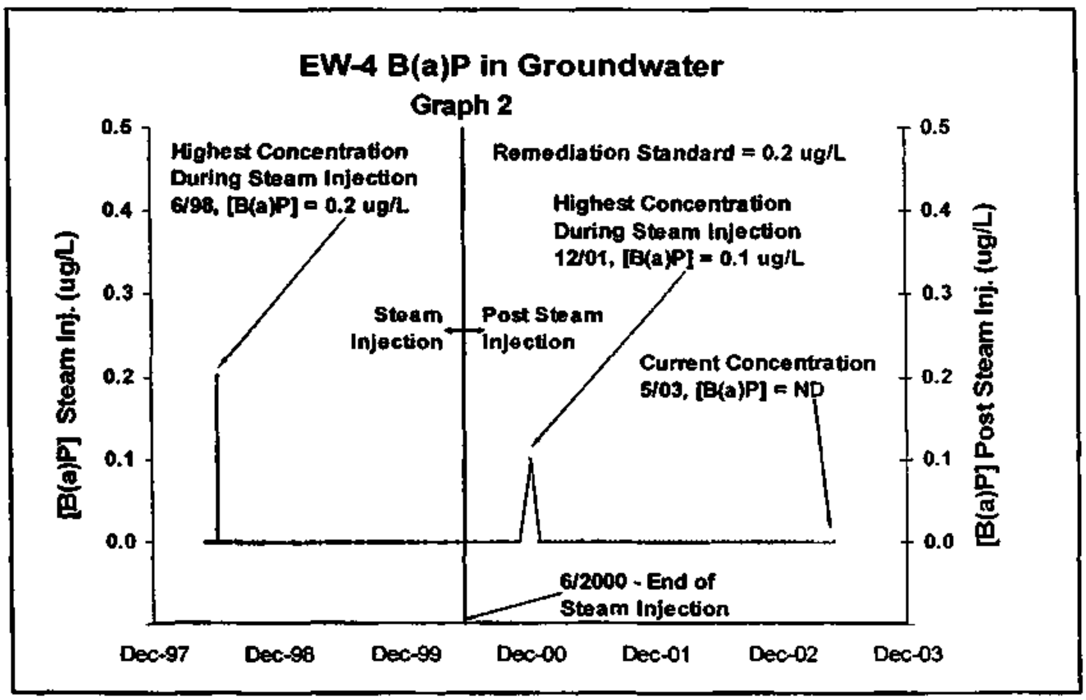
Observations over the past 60 months of the groundwater quality in other wells located at the site suggests B(a)P and Dioxins have not been mobilized to any degree beyond the original source area. The observations may not be entirely representative, however, the in the ensuing time period since the project initiation, the empirical observations of the groundwater quality have produced encouraging results and achieving the stated goals appears to be certain.

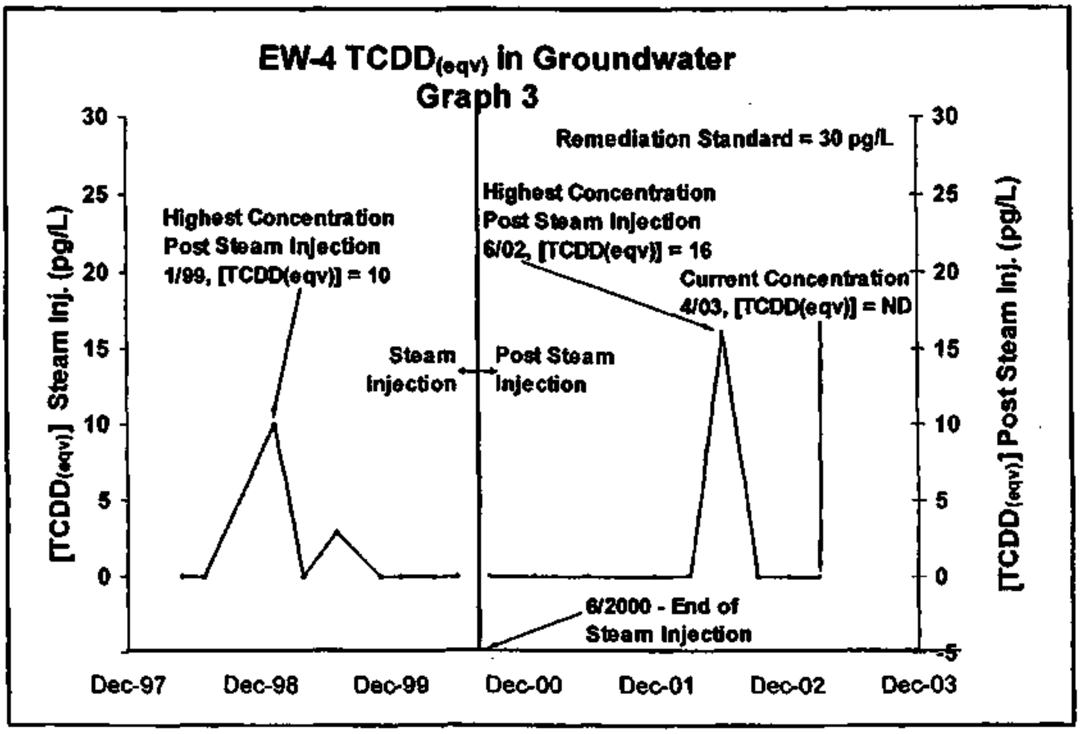
Future Objectives: The compliance plan negotiated with the California EPA–Department of Toxic Substances Control calls for the demonstration of compliance at a point along the western boundary of the Visalia Pole Yard property. The "compliance point" will be three dedicated monitoring wells, which are scheduled for completion by 3rd quarter of 2003. Upon completion of these wells, SCE will enter into a regulatory demonstration phase to show compliance with the remediation standards as listed above. The details of the monitoring program and data reduction methods have yet to be determined and subsequently approved by DTSC.

The EW-4 groundwater quality continues to improve, and as of May 2003, meets all of the regulatory objectives. Upon completion of the monitoring wells, SCE will continue with monthly assays of each of the wells. A representative data base will be collected and a final decision will be made to discontinue the operation of the Visalia Water Treatment Plant. The water treatment plant will held in a "wet" standby status to insure a "back-up" remedy is available. The duration of the standby status of the water treatment plant has yet to be determined.

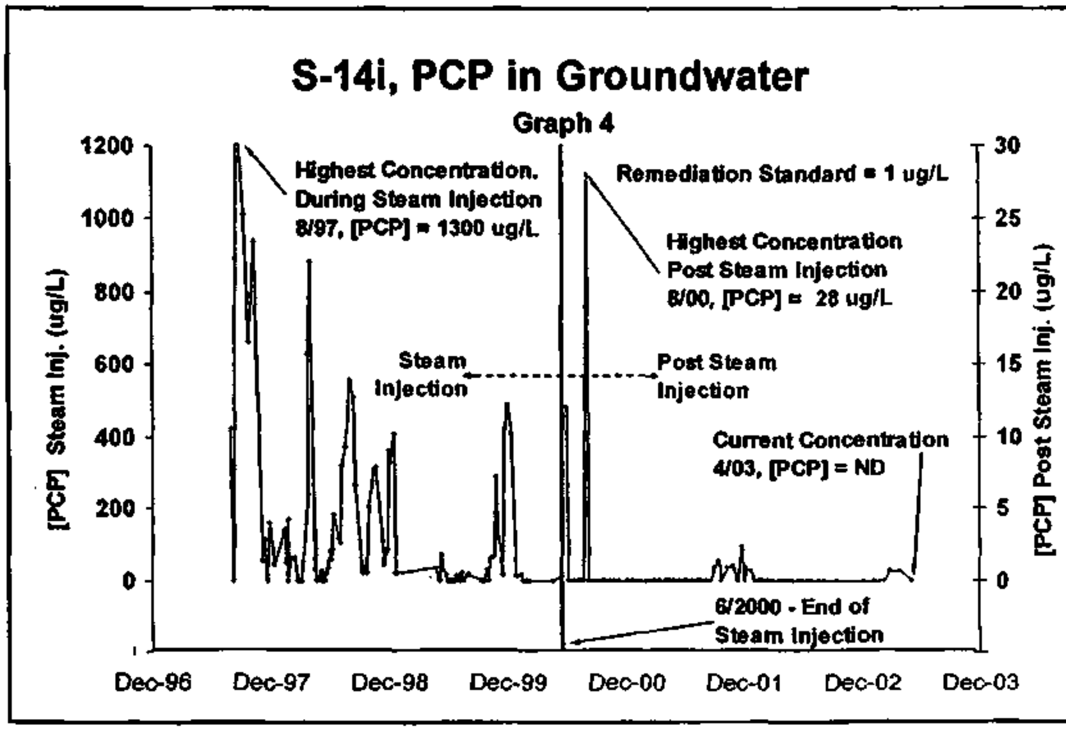
Graphs and Figure

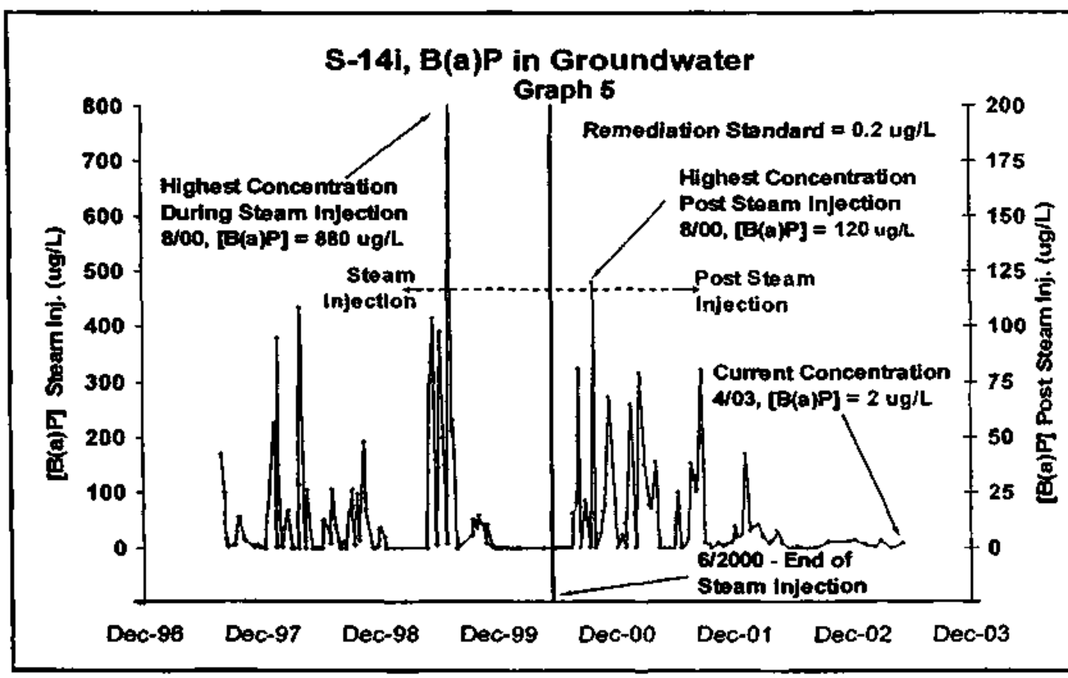

EW-4 PCP in Groundwater
Graph 1
Highest Concentratrion
During Steam Injection
2/99, [PCP] = 371 ug/L
Remediation Standard = 1 ug/L
Highest Concentratrion
Post Steam Injection
2/99, [PCP] = 120 ug/L
4/2003 Concentration
[PCP] = 0.6 ug/L
Steam
Injection
Post Steam
Injection
6/2000 - End of
Steam Injection
[PCP] Steam Inj. (ug/L)
[PCP] Post Steam Inj. (ug/L)
500
400
300
200
100
0
100
80
60
40
20
0
Dec-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03

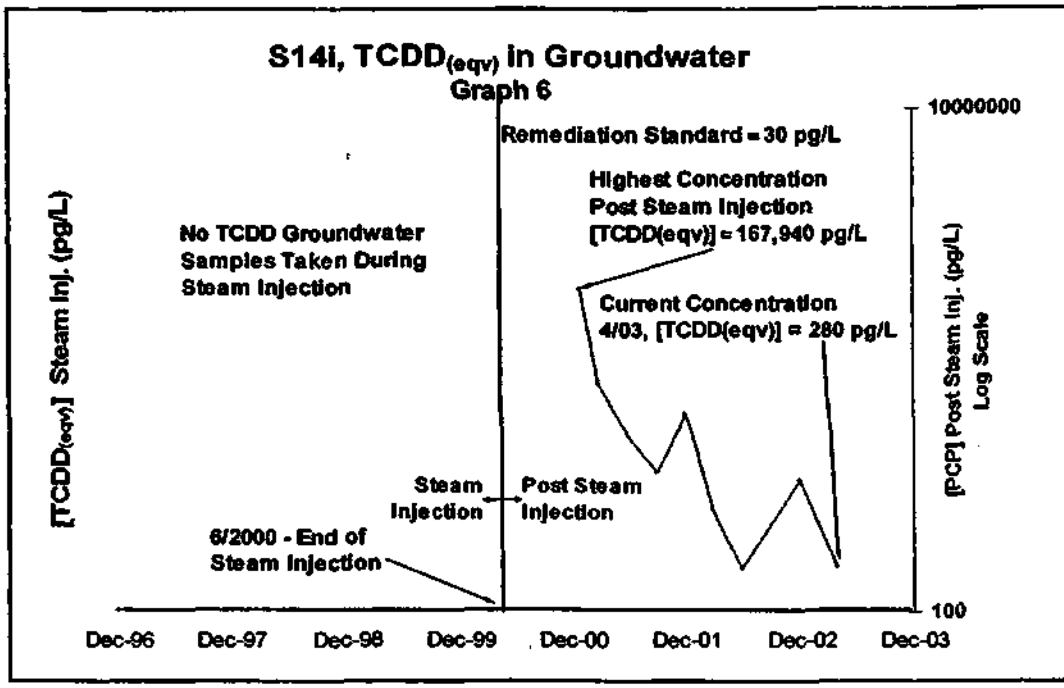

EW-4 B(a)P in Groundwater
Graph 2
Highest Concentration
During Steam Injection
6/98, [B(a)P] = 0.2 ug/L
Remediation Standard = 0.2 ug/L
Highest Concentration
During Steam Injection
12/01, [B(a)P] = 0.1 ug/L
Steam
Injection
Post Steam
Injection
Current Concentration
5/03, [B(a)P] = ND
6/2000 - End of
Steam Injection
[B(a)P] Steam Inj. (ug/L)
[B(a)P] Post Steam Inj. (ug/L)
0.5
0.4
0.3
0.2
0.1
0.0
Dec-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03



EW-4 TCDD(eqv) in Groundwater
Graph 3
Remediation Standard = 30 pg/L
Highest Concentration
Post Steam Injection
1/99, [TCDD(eqv)] = 10
Highest Concentration
Post Steam Injection
6/02, [TCDD(eqv)] = 16
Current Concentration
4/03, [TCDD(eqv)] = ND
Steam Injection
Post Steam Injection
6/2000 - End of Steam Injection
[TCDD(eqv)] Steam Inj. (pg/L)
[TCDD(eqv)] Post Steam Inj. (pg/L)
30
25
20
15
10
5
0
-5
Dec-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03


S-14i, PCP in Groundwater
Graph 4
Highest Concentration. During Steam Injection 8/97, [PCP] = 1300 ug/L
Remediation Standard = 1 ug/L
Highest Concentration Post Steam Injection 8/00, [PCP] = 28 ug/L
Steam Injection
Post Steam Injection
Current Concentration 4/03, [PCP] = ND
6/2000 - End of Steam Injection
[PCP] Steam Inj. (ug/L)
[PCP] Post Steam Inj. (ug/L)
1200
1000
800
600
400
200
0
30
25
20
15
10
5
0
Dec-96
Dec-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03


S-14i, B(a)P in Groundwater
Graph 5
Remediation Standard = 0.2 ug/L
Highest Concentration During Steam Injection 8/00, [B(a)P] = 880 ug/L
Highest Concentration Post Steam Injection 8/00, [B(a)P] = 120 ug/L
Steam Injection
Post Steam Injection
Current Concentration 4/03, [B(a)P] = 2 ug/L
6/2000 - End of Steam Injection
[B(a)P] Steam Inj. (ug/L)
[B(a)P] Post Steam Inj. (ug/L)
800
700
600
500
400
300
200
100
0
200
175
150
125
100
75
50
25
0
Dec-96
Dec-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03


S14i, TCDD(eqv) in Groundwater
Graph 6
Remediation Standard = 30 pg/L
Highest Concentration
Post Steam Injection
[TCDD(eqv)] = 167,940 pg/L
No TCDD Groundwater
Samples Taken During
Steam Injection
Current Concentration
4/03, [TCDD(eqv)] = 280 pg/L
Steam
Injection
Post Steam
Injection
6/2000 - End of
Steam Injection
[TCDD(eqv)] Steam Inj. (pg/L)
[PCP] Post Steam Inj. (pg/L)
Log Scale
10000000
100
Dec-96
Dec-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03

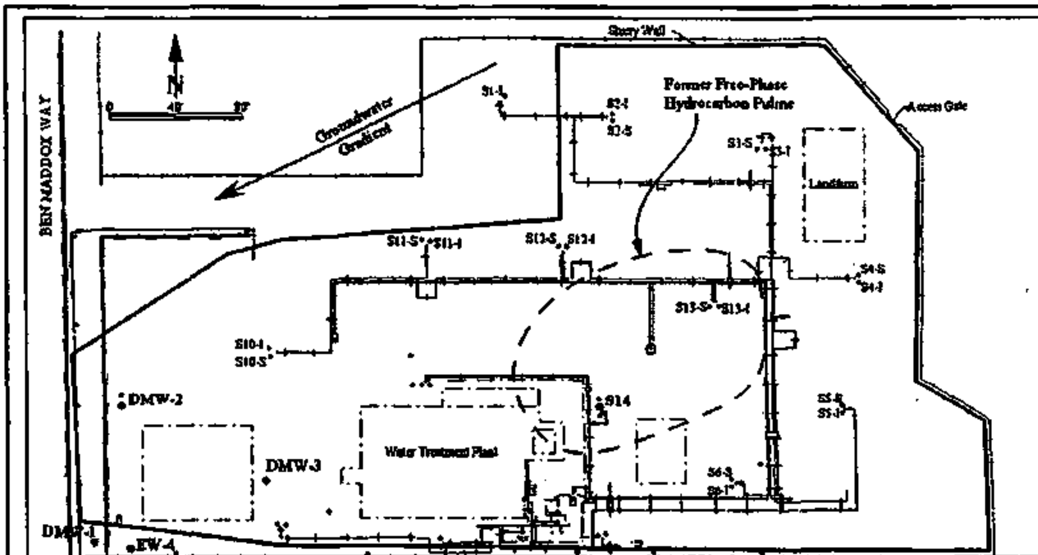

BEN MADDOX WAY
N
Groundwater
Gradient
Slurry Wall
Former Free-Phase
Hydrocarbon Plume
Access Gate
Landfarm
Water Treatment Plant
DMW-2
DMW-3
DMW-1
EW-4
S14

Figure 1

APPENDIX J
IAS CALCULATIONS

MEMORANDUM

THE FORRESTER GROUP
INSIGHTFUL ENVIRONMENTAL SOLUTIONS

Date: October 29, 2003

To: File

From: Jay Hoskins

Subject: UPRR Ogden Rail Yard
Calculations for Modeling IAS Cleanup Time

Preliminary calculations were performed using An IAS/SVE spreadsheet model developed by O'Neill and Symons.[1] The purpose of the calculations was to estimate groundwater cleanup times during in situ air sparging (IAS) of the areas of highest CVOC concentrations in the northern CVOC plume. A sensitivity analysis was also conducted, considering potential variability in fraction of organic carbon (f_{oc}) and hydraulic conductivity. Calculations were performed for VC and 1,1,1-TCA.[2] The groundwater concentrations for VC and 1,1,1-TCA at the start of IAS were assumed to be 2.2 mg/L.[3] This value is intended to represent a reasonable estimate of the high end of 1,1,1-TCA and VC concentrations in this area.

A set of IAS parameters intended to represent the "best estimate" of site conditions was developed (Table 1). The parameters used to develop the "best estimate" are derived either from site specific tests, literature, or assumptions on the air sparging process (e.g., air flow rate and radius of sparging well influence). Results indicate the following:

- The 1,1,1-TCA concentration was reduced from 2.2 mg/L to 0.001 mg/L (1 ug/L) in two years of treatment (Table 2).
- The VC concentration was reduced to less than 0.001 mg/L (1 ug/L) in just a few days. (Table 3).

Sensitivity calculations were performed to determine what affect an order of magnitude reduction in hydraulic conductivity (and groundwater flow velocity) could have on model predictions. Parameters used in this analysis are shown in Table 4.

- The 1,1,1-TCA concentration was reduced from 2.2 mg/L to 0.002 mg/L (2 ug/L) in three years of treatment. (Table 5)
- The VC concentration was reduced to less than 0.0001 mg/L (1 ug/L) in just a few days. (Table 6)

[1] A paper presented to University of Massachusetts-Amherst describing this model is available upon request.

[2] Vinyl chloride is the chemical most widely distributed in the northern plume; 1,1,1-TCA is a parent chemical of vinyl chloride frequently detected in this area of the northern plume.

[3] Based on concentration data from 38-MW12 and 22a-MW6, two north plume wells with frequently elevated detections of vinyl chloride and 1,1,1-TCA. 1,1,1-TCA has been measured at 38-MW12 at concentrations of 2000-4100 ug/L; all but one detection was below 2700 ug/L; VC has been measured at concentrations of 830-2300 ug/L

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Sensitivity calculations were performed to determine what affect a f_{oc} value of 0.01 could have on treatment times. Based on site specific measurements, this is believed to be near the upper range of f_{oc} values at the site. Parameters used in this analysis are shown in Table 7

- The 1,1,1-TCA concentration was reduced from 2.2 mg/L to less than 0.001 mg/L (1 ug/L) in less than three years. (Table 8)

- The VC concentration was reduced to less than 0.001 mg/L (1 ug/L) in just a few days. (Table 9)

CONCLUSIONS

Based on preliminary calculations, significant reductions in VC concentrations could occur very soon after treatment is initiated. IAS could potentially reduce 1,1,1-TCA concentrations to low levels (less than 1 ug/L) in a few years. Given that the reduction in 1,1,1-TCA levels to very low levels is necessary to achieve acceptable VC concentrations downgradient of the sparging zone, the total treatment time could be a few years.

Calculations do not account for inefficiencies in treatment effectiveness. Examples include inadequate contact between air bubbles and impacted media, the inability for air bubbles to reach impacted media due to subsurface heterogeneity (i.e. a lens of silt or silty clay in the sparging zone), or short-circuiting of air bubbles through preferential flow paths. Also, there is considerable uncertainty about the mass of source material. If pockets of DNAPL exist, then the treatment time could be substantially increased because the mass of CVOCs could be greater than this model accounts for. Due to all of these factors, there is considerable uncertainty in these calculations.

These calculated treatment times are appropriate for developing feasibility level cost estimates for the purpose of comparing alternatives. However given the uncertainty factors discussed above, these calculations should not be used as an exact prediction of IAS performance or cleanup times.

Table 1
Design Parameters: Best Estimate Conditions

Parameters	Values	Units	Notes
Groundwater flow rate	2500	ft^3/day	
Module Area	44100	ft^2	Area of one module
Well Depth	20	ft	Average depth over N. Plume
Saturated Depth	10.5	ft	Average Depth
Water Volume	92610	ft^3	V=AxDsxn, n=0.2
Hydraulic Conductivity	280	ft/day	Northern Area Pumping Test Data
Gradient	0.004	unitless	Groundwater Contour Map
Fraction of Organic Carbon in Soil	0.004	unitless	Average value of tests
Soil Partitioning Coefficient (Koc-VC)	0.407	L/kg	RI appendix L
Soil Partitioning Coefficient (Kd-VC)	0.004	L/kg	RI appendix L
Soil Partitioning Coefficient (Kd-VC)	6.36E-05	ft^3/lb	Unit conversion
Oil/Water Patitioning Coefficient (VC)	3.91	unitless	logkoc=0.999logKow-0.202
Soil Partitioning Coefficient (Koc-TCA)	183	L/kg	Literature
Soil Partitioning Coefficient (Kd-TCA)	0.55	L/kg	Literature
Soil Partitioning Coefficient (Kd-TCA)	0.009	ft^3/lb	Unit conversion
Oil/Water Patitioning Coefficient (TCA)	242.32	unitless	logkoc=0.999logKow-0.202
Fraction of Air	0.05	unitless	Typical Default Value
Density of Soil	102	lb/ft^3	Typical Default Value
Fraction Water (Porosity)	0.2	unitless	Typical Default Value
Fraction Soil	0.75	unitless	Typical Default Value
Fraction Oil	0	unitless	Typical Default Value
Volatilization Eff. Factor	0.05	unitless	Typical Default Value
Biodegradation Eff. Factor	0.05	unitless	Typical Default Value
Radius of influence	21	ft	Well spacing
Number of West Parcel Wells	25	wells	Figure 4-1 of FS
Number of East Parcel Wells	0	wells	Figure 4-1 of FS
Sparge Design Flow Rate	5	scfm	Adjustable, determined during startup

TABLE 2
TYPICAL AIR SPARGING PERFORMANCE, FIRST ORDER BIODEGRADATION RATE, 1,1,1-TCA (Cleanup Time Calculations)

Assumptions
Aquifer Conditions

	Units	Conditions	Stands For
Q_i=	2500 ft³/day		Groundwater flow rate
V_T=	463,050 ft³		Plume Area * Sat. Thickness
X_a=	0.05		Fraction of Air
P_s=	102 lb/ft³	Dry basis	Density of Soil
X_w=	0.20	Porosity	Fraction Water
X_s=	0.75	Solids	Fraction Soil
X_o=	0		Fraction Oil
zv=	0.05		Efficiency factor
Q_a=	180,000 ft³/day		Air Flow Rate

Contaminant

		VC Units	Stands for
Kd=	0.009	ft³/lb	Soil Partition Coefficient
Ko=	242.32		Oil Partition Coefficient
k=	0.0000	/day	Decay Rate (assumed to be 0)
Kh=	0.3300	dimensionless	Air Partition Coefficient (Henry's)

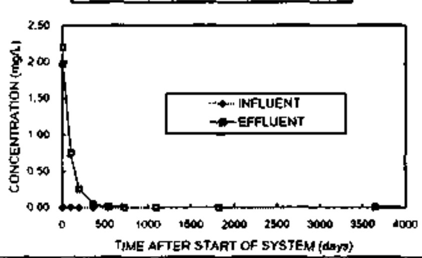
Equations
Cw(t)=((YCw(0)+B)*exp(Yt)-B)/Y
Ca(t)= Kh z Cw(t)

$C_{w(0)}$= 0.000137 lb/ft³
$C_{w(0)}$= 2.2 mg/L
$C_{w(in)}$= 0 lb/ft³
$C_{w(in)}$= 0 mg/L

Y= -1.08E-02 1/day   Y = $Y = \dfrac{-[Q_i/V_T + k(X_w + P_s Ks) + Q_a/V_T Kh\, z]}{(X_w + P_s Ks + X_a Kh\, z + X_o Ko)}$

B= 0.00E+00 lbs/ft³ day   B = $B = \dfrac{Q_i/V_T\, C_{w(0)}}{(X_w + P_s Ks + X_a Kh\, z + X_o Ko)}$

ESTIMATED AIR SPARGING PERFORMANCE



Time years	Time days	$C_{w(t)}$ (mg/l)	$C_{a(t)}$ (mg/m³)
	0	2.200	36
	10	1.974	33
	100	0.746	12
	200	0.253	4
1	365	0.042	1
1.5	547.5	0.006	0
2	730	0.001	0
3	1095	0.000	0
5	1825	0.000	0
10	3650	0.000	0
15	5475	0.000	0

MASS BALANCE (lbs)

SYSTEM(a) MASS	TRENCH GW CONC.	TRENCH Air Conc	TRENCH Oil Conc	TRENCH SOIL CONC.	INFLUENT(b) (lbs)	BIO.(c) (lbs)	VENTED(d) (lbs)	EFFLUENT(e) (lbs)
69.4	12.8	0.1	0.0	56.6	0.0	(2.1)	3.9	3.3
64.4	13.5	0.0	0.0	50.8	0.0	(0.9)	22.7	19.1
23.5	4.3	0.0	0.0	19.2	0.0	(1.5)	9.3	7.8
8.0	1.5	0.0	0.0	6.5	0.0	(1.7)	4.5	3.8
1.3	0.2	0.0	0.0	1.1	0.0	(0.4)	0.8	0.7
0.2	0.0	0.0	0.0	0.2	0.0	(0.0)	0.1	0.1
0.0	0.0	0.0	0.0	0.0	0.0	(0.0)	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	(0.0)	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	(0.0)	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total 0.0	0.0	0.0	0.0	0.0	0.0	-6.6	41.3	34.7

Note:
(a) Initial Mass = GW mass + Soil Mass + Oil Mass + Vapor Mass = $C_{w(t)} * V_T * (X_w + (P_s * Ks)) + C_{a(t)} * X_a * V_T + X_o * Ko * V_T$
(b) Influent Mass = $C_{w(t)}$ * Qi * (Time)
(c) Biodegraded Mass = Initial mass - Final mass + Influent Mass - Vented Mass - Effluent Mass
(d) Vented Mass = $C_{a,avg(t)} * Q_a$ * (Time)
(e) Effluent Mass = $C_{w\,avg(t)}$ * Qi * (Time)

O2 Delivered
Q*0.0175 lbs o2/ft3 air* zb
157.5 lbs O2/day

Saturation O2
8 mg/L*Qw
1.248 lbo2/day

Consumed per day
3.5lb O2/lb HC degraded
0.00 lbo2/day

Total Mass O2 required
1.25 lb o2/day

Air flow Required to have 0 excess
1424.09 ft3/day
0.04 cfm/well

TABLE 3
TYPICAL AIR SPARGING PERFORMANCE, FIRST ORDER BIODEGRADATION RATE, VC (Cleanup Time Calculations)

Assumptions

Aquifer Conditions

		Units	Conditions	Stands For
Q_i=	2500	ft^3/day		Groundwater flow rate
V_T=	463,050	ft^3		Plume Area * Sat. Thickness
X_a=	0.05			Fraction of Air
P_s=	102	lb/ft^3	Dry basis	Density of Soil
X_w=	0.20		Porosity	Fraction Water
X_s=	0.75		Solids	Fraction Soil
X_o=	0			Fraction Oil
zv=	0.05			Efficiency factor
Q_a=	180,000	ft^3/day		Air Flow Rate

Contaminant VC

		Units	Stands for
Kd=	0.000	ft^3/lb	Soil Partition Coefficient
Ko=	3.91		Oil Partition Coefficient
k=	0.6200	/day	Decay Rate (based on pilot study)
Kh=	50.0000	dimensionless	Air Partition Coefficient (Henry's)

Equations

Cw(t)=((YCw(0)+B)*exp(Yt)-B)/Y

Ca(t)= Kh z Cw(t)

$C_{w(0)}$= 0.000143 lb/ft^3

$C_{w(0)}$= 2.3 mg/L

$C_{w(in)}$= 0 lb/ft^3

$C_{w(in)}$= 0 mg/L

Y= -3.33E+00 1/day

B= 0.00E+00 lbs/ft^3 day

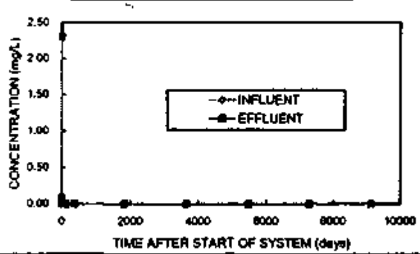
Y =

B =

$$Y = \frac{-[Q_i/V_T + k(X_w + P_s Ks) + Q_a/V_T Kh z]}{(X_w + P_s Ks + X_a Kh z + X_o Ko)}$$

$$B = \frac{Q_i/V_T C_{w(0)}}{(X_w + P_s Ks + X_a Kh z + X_o Ko)}$$

ESTIMATED AIR SPARGING PERFORMANCE



Time years	Time days	$C_{w(t)}$ (mg/l)	$C_{a(t)}$ (mg/m³)
	0	2.300	5,750
	1	0.082	205
	10	0.000	0
	100	0.000	0
1	365	0.000	0
5	1825	0.000	0
10	3650	0.000	0
15	5475	0.000	0
20	7300	0.000	0
25	9125	0.000	0
30	10950	0.000	0

MASS BALANCE (lbs)

SYSTEM(a) MASS	TRENCH GW CONC.	TRENCH Air Conc	TRENCH Oil Conc	TRENCH SOIL CONC.	INFLUENT(b) (lbs)	BIO.(c) (lbs)	VENTED(d) (lbs)	EFFLUENT(e) (lbs)
22.1	13.4	8.3	0.0	0.4	0.0	(12.3)	33.5	0.2
0.8	0.5	0.3	0.0	0.0	0.0	(9.8)	10.4	0.1
0.0	0.0	0.0	0.0	0.0	0.0	(0.0)	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	(0.0)	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Total	0.0	0.0	0.0	0.0	0.0	-21.8	43.6	0.2

O2 Delivered
Q*0.0175 lbs o2/ft3 air* zb
157.5 lbs O2/day

Saturation O2
8 mg/L*Qw
1.246 lbo2/day

Consumed per day
3.6lb 02/lb HC degraded
0.00 lbo2/day

Total Mass O2 required
1.25 lb o2/day

Air flow Required to have 0 excess
1424.09 ft3/day
0.04 cfm/well

Note:

(a) Initial Mass = GW mass + Soil Mass + Oil Mass + Vapor Mass = $C_{w(t)} * V_T * (X_w + (P_s * Ks)) + C_{a(t)} * X_a * V_T + X_o * Ko * V_T$

(b) Influent Mass = $C_{w(i)}$ * Qi * (Time)

(c) Biodegraded Mass = Initial mass - Final mass + Influent Mass - Vented Mass - Effluent Mass

(d) Vented Mass = $C_{a,avg(t)}$ * Q_a * (Time)

(e) Effluent Mass = $C_{w,avg(t)}$ * Qi * (Time)

Table 4
Design Parameters: Hydraulic Conductivity Sensitivity

Parameters	Values	Units	Notes
Groundwater flow rate	250	ft^3/day	
Module Area	44100	ft^2	Area of one module
Well Depth	20	ft	Average depth over N. Plume
Saturated Depth	10.5	ft	Average Depth
Water Volume	92610	ft^3	V=AxDsxn, n=0.2
Hydraulic Conductivity	28	ft/day	Northern Area Pumping Test Data x 0.1
Gradient	0.004	unitless	Groundwater Contour Map
Fraction of Organic Carbon in Soil	0.004	unitless	Average value of tests
Soil Partitioning Coefficient (Koc-VC)	0.407	L/kg	RI appendix L
Soil Partitioning Coefficient (Kd-VC)	0.004	L/kg	RI appendix L
Soil Partitioning Coefficient (Kd-VC)	6.36E-05	ft^3/lb	Unit conversion
Oil/Water Patitioning Coefficient (VC)	3.91	unitless	logkoc=0.999logKow-0.202
Soil Partitioning Coefficient (Koc-TCA)	183	L/kg	Literature
Soil Partitioning Coefficient (Kd-TCA)	0.55	L/kg	Literature
Soil Partitioning Coefficient (Kd-TCA)	0.009	ft^3/lb	Unit conversion
Oil/Water Patitioning Coefficient (TCA)	242.32	unitless	logkoc=0.999logKow-0.202
Fraction of Air	0.05	unitless	Typical Default Value
Density of Soil	102	lb/ft^3	Typical Default Value
Fraction Water (Porosity)	0.2	unitless	Typical Default Value
Fraction Soil	0.75	unitless	Typical Default Value
Fraction Oil	0	unitless	Typical Default Value
Volatilization Eff. Factor	0.05	unitless	Typical Default Value
Biodegradation Eff. Factor	0.05	unitless	Typical Default Value
Radius of influence	21	ft	Well spacing
Number of West Parcel Wells	25	wells	Figure 4-1 of FS
Number of East Parcel Wells	0	wells	Figure 4-1 of FS
Sparge Design Flow Rate	5	scfm	Adjustable, determined during startup

TABLE 5
TYPICAL AIR SPARGING PERFORMANCE, FIRST ORDER BIODEGRADATION RATE, 1,1,1-TCA (Cleanup Time Calculations)

Assumptions

Aquifer Conditions

		Units	Conditions	Stands For
Q_i=	250	ft³/day		Groundwater flow rate
V_T=	463,050	ft³		Plume Area * Sat. Thickness
X_a=	0.05			Fraction of Air
P_s=	102	lb/ft³	Dry basis	Density of Soil
X_w=	0.20		Porosity	Fraction Water
X_s=	0.75		Solids	Fraction Soil
X_o=	0			Fraction Oil
zv=	0.05			Efficiency factor
Q_a=	180,000	ft³/day		Air Flow Rate

Contaminant:

		VC Units	Stands for
Kd=	0.009	ft³/lb	Soil Partition Coefficient
Ko=	242.32		Oil Partition Coefficient
k=	0.0000	/day	Decay Rate (assumed to be 0)
Kh=	0.3300	dimensionless	Air Partition Coefficient (Henry's)

Equations

Cw(t)=((YCw(0)+B)*exp(Yt)-B)/Y

Ca(t)= Kh z Cw(t)

$C_{w(0)}$= 0.000137 lb/ft³

$C_{w(0)}$= 2.2 mg/L

$C_{w(in)}$= 0 lb/ft³

$C_{w(in)}$= 0 mg/L

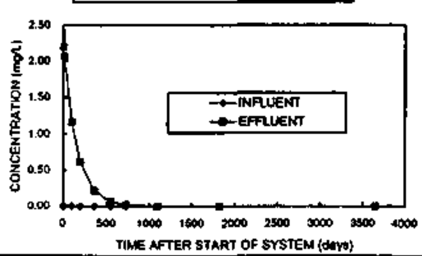
Y= -6.37E-03 1/day

B= 0.00E+00 lbs/ft³ day

$$Y = \frac{-[Q_i/V_T + k(X_w + P_s\,Ks) + Q_a/V_T\,Kh\,z]}{(X_w + P_s\,Ks + X_a\,Kh\,z + X_o\,Ko)}$$

$$B = \frac{Q_i/V_T\,C_{w(0)}}{(X_w + P_s\,Ks + X_a\,Kh\,z + X_o\,Ko)}$$

ESTIMATED AIR SPARGING PERFORMANCE



Time years	Time days	$C_{w(t)}$ (mg/l)	$C_{a(t)}$ (mg/m³)	SYSTEM(a) MASS	TRENCH GW CONC.	TRENCH Air Conc	TRENCH Oil Conc	TRENCH SOIL CONC.	INFLUENT(b) (lbs)	BIO.(c) (lbs)	VENTED(d) (lbs)	EFFLUENT(e) (lbs)
	0	2.200	36	69.4	12.8	0.1	0.0	56.6	0.0	(3.3)	4.0	0.3
	10	2.064	34	68.4	15.3	0.0	0.0	53.1	0.0	2.5	26.9	2.3
	100	1.164	19	36.7	6.7	0.0	0.0	29.9	0.0	(0.9)	16.5	1.4
	200	0.615	10	19.4	3.6	0.0	0.0	15.8	0.0	(1.2)	12.7	1.1
1	365	0.215	4	6.8	1.2	0.0	0.0	5.5	0.0	(0.5)	4.8	0.4
1.5	547.5	0.067	1	2.1	0.4	0.0	0.0	1.7	0.0	(0.2)	1.5	0.1
2	730	0.021	0	0.7	0.1	0.0	0.0	0.5	0.0	(0.2)	0.8	0.1
3	1095	0.002	0	0.1	0.0	0.0	0.0	0.1	0.0	(0.1)	0.1	0.0
5	1825	0.000	0	0.0	0.0	0.0	0.0	0.0	0.0	(0.0)	0.0	0.0
10	3650	0.000	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	5475	0.000	0									
				Total	0.0	0.0	0.0	0.0	0.0	-3.5	67.3	5.7

Note:

(a) Initial Mass = GW mass + Soil Mass + Oil Mass + Vapor Mass = $C_{w(t)} * V_T * (X_w + (P_s * Ks)) + C_{a(t)} * X_a * V_T + X_o * Ko * V_T$

(b) Influent Mass = $C_{w(i)} * Qi * (\text{Time})$

(c) Biodegraded Mass = Initial mass - Final mass + Influent Mass - Vented Mass - Effluent Mass

(d) Vented Mass = $C_{a,avg(t)} * Q_a * (\text{Time})$

(e) Effluent Mass = $C_{w,avg(t)} * Qi * (\text{Time})$

O2 Delivered
Q*0.0175 lbs o2/ft3 air* zb
157.5 lbs O2/day

Saturation O2
8 mg/L*Qw
0.125 lbo2/day

Consumed per day
3.5lb 02/lb HC degraded
0.00 lbo2/day

Total Mass O2 required
0.12 lb o2/day

Air flow Required to have 0 excess
142.41 ft3/day
0.00 cfm/well

TABLE 6
TYPICAL AIR SPARGING PERFORMANCE, FIRST ORDER BIODEGRADATION RATE, VC (Cleanup Time Calculations)

Assumptions
Aquifer Conditions

	Value	Units	Conditions	Stands For
Q_i=	250	ft^3/day		Groundwater flow rate
V_T=	463,050	ft^3		Plume Area * Sat. Thickness
X_a=	0.05			Fraction of Air
P_s=	102	lb/ft^3	Dry basis	Density of Soil
X_w=	0.20		Porosity	Fraction Water
X_s=	0.75		Solids	Fraction Soil
X_o=	0			Fraction Oil
zv=	0.05			Efficiency factor
Q_a=	180,000	ft^3/day		Air Flow Rate

Contaminant **VC**

	Value	Units	Stands for
Kd=	0.000	ft^3/lb	Soil Partition Coefficient
Ko=	3.91		Oil Partition Coefficient
k=	0.6200	/day	Decay Rate (based on pilot study)
Kh=	50.0000	dimensionless	Air Partition Coefficient (Henry's)

Equations

$Cw(t)=((YCw(0)+B)^*exp(Yt)-B)/Y$

$Ca(t)= Kh\ z\ Cw(t)$

$C_{w(0)}$= 0.000143 lb/ft^3

$C_{w(0)}$= 2.3 mg/L

$C_{w(in)}$= 0 lb/ft^3

$C_{w(in)}$= 0 mg/L

Y= -3.32E+00 1/day

B= 0.00E+00 lbs/ft^3 day

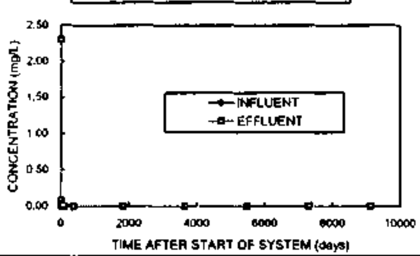
Y =

$$Y = \frac{-[Q_i/V_T + k(X_w + P_s Ks) + Q_a/V_T\ Kh\ z]}{(X_w + P_s\ Ks + X_a\ Kh\ z + X_o\ Ko)}$$

B =

$$B = \frac{Q_i/V_T\ C_{w(0)}}{(X_w + P_s\ Ks + X_a\ Kh\ z + X_o\ Ko)}$$

ESTIMATED AIR SPARGING PERFORMANCE



Time years	Time days	$C_{w(t)}$ (mg/l)	$C_{a(t)}$ (mg/m³)	SYSTEM(a) MASS	TRENCH GW CONC.	TRENCH Air Conc	TRENCH Oil Conc	TRENCH SOIL CONC.	INFLUENT(b) (lbs)	BIO.(c) (lbs)	VENTED(d) (lbs)	EFFLUENT(e) (lbs)
				MASS BALANCE (lbs)								
	0	2.300	5.750	22 1	13.4	8.3	0.0	0.4	0.0	(12.2)	33.5	0.0
	1	0.083	208	0.8	0.5	0.3	0.0	0.0	0.0	(8.7)	10.5	0.0
	10	0.000	0	0.0	0.0	0.0	0.0	0.0	0.0	(0.0)	0.0	0.0
	100	0.000	0	0.0	0.0	0.0	0.0	0.0	0.0	(0.0)	0.0	0.0
1	365	0.000	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	1825	0.000	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	3650	0.000	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	5475	0.000	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	7300	0.000	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	9125	0.000	0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
30	10950	0.000	0									
				Total	0.0	0.0	0.0	0.0	0.0	-21.8	44.0	0.0

O2 Delivered
Q*0.0175 lbs o2/ft3 air* zb
157.5 lbs O2/day

Saturation O2
8 mg/L*Qw
0.125 lbo2/day

Consumed per day
3.5lb 02/lb HC degraded
0.00 lbo2/day

Total Mass O2 required
0.12 lb o2/day

Air flow Required to have 0 excess
142.41 ft3/day
0.00 cfm/well

Note

(a) Initial Mass = GW mass + Soil Mass + Oil Mass + Vapor Mass = $C_{w(t)} * V_T * (X_w + (P_s * Ks)) + C_{a(t)} * X_a * V_T + X_o * Ko * V_T$

(b) Influent Mass = $C_{w(t)}$ * Qi * (Time)

(c) Biodegraded Mass = Initial mass - Final mass + Influent Mass - Vented Mass - Effluent Mass

(d) Vented Mass = $C_{a,avg(t)}$ * Q_a * (Time)

(e) Effluent Mass = $C_{w,avg(t)}$ * Qi * (Time)

Table 7
Design Parameters: f_{oc} Sensitivity

Parameters	Values	Units	Notes
Groundwater flow rate	2500	ft^3/day	
Module Area	44100	ft^2	Area of one module
Well Depth	20	ft	Average depth over N. Plume
Saturated Depth	10.5	ft	Average Depth
Water Volume	92610	ft^3	V=AxDsxn, n=0.2
Hydraulic Conductivity	280	ft/day	Northern Area Pumping Test Data
Gradient	0.004	unitless	Groundwater Contour Map
Fraction of Organic Carbon in Soil	0.009	unitless	High range of tests
Soil Partitioning Coefficient (Koc-VC)	0.407	L/kg	RI appendix L
Soil Partitioning Coefficient (Kd-VC)	0.004	L/kg	RI appendix L
Soil Partitioning Coefficient (Kd-VC)	6.36E-05	ft^3/lb	Unit conversion
Oil/Water Patitioning Coefficient (VC)	3.91	unitless	logkoc=0.999logKow-0.202
Soil Partitioning Coefficient (Koc-TCA)	183	L/kg	Literature
Soil Partitioning Coefficient (Kd-TCA)	0.55	L/kg	Literature
Soil Partitioning Coefficient (Kd-TCA)	0.010	ft^3/lb	Unit conversion
Oil/Water Patitioning Coefficient (TCA)	242.32	unitless	logkoc=0.999logKow-0.202
Fraction of Air	0.05	unitless	Typical Default Value
Density of Soil	102	lb/ft^3	Typical Default Value
Fraction Water (Porosity)	0.2	unitless	Typical Default Value
Fraction Soil	0.75	unitless	Typical Default Value
Fraction Oil	0	unitless	Typical Default Value
Volatilization Eff. Factor	0.05	unitless	Typical Default Value
Biodegradation Eff. Factor	0.05	unitless	Typical Default Value
Radius of influence	21	ft	Well spacing
Number of West Parcel Wells	25	wells	Figure 4-1 of FS
Number of East Parcel Wells	0	wells	Figure 4-1 of FS
Sparge Design Flow Rate	5	scfm	Adjustable, determined during startup

TABLE 8
TYPICAL AIR SPARGING PERFORMANCE, FIRST ORDER BIODEGRADATION RATE, 1,1,1-TCA (Cleanup Time Calculations)

Assumptions

Aquifer Conditions		Units	Conditions	Stands For
Q_i=	2500	ft³/day		Groundwater flow rate
V_T=	463,050	ft³		Plume Area * Sat. Thickness
X_a=	0.05			Fraction of Air
P_s=	102	lb/ft³	Dry basis	Density of Soil
X_w=	0.20		Porosity	Fraction Water
X_s=	0.75		Solids	Fraction Soil
X_o=	0			Fraction Oil
zv=	0.05			Efficiency factor
Q_a=	180,000	ft³/day		Air Flow Rate

Contaminant	VC	Units	Stands for
Kd=	0.010	ft³/lb	Soil Partition Coefficient
Ko=	242.32		Oil Partition Coefficient
k=	0.0000	/day	Decay Rate (assumed to be 0)
Kh=	0.3300	dimensionless	Air Partition Coefficient (Henry's)

Equations

Cw(t)=((YCw(0)+B)*exp(Yt)-B)/Y

Ca(t)= Kh z Cw(t)

$C_{w(0)}$= 0.000137 lb/ft³

$C_{w(0)}$= 2.2 mg/L

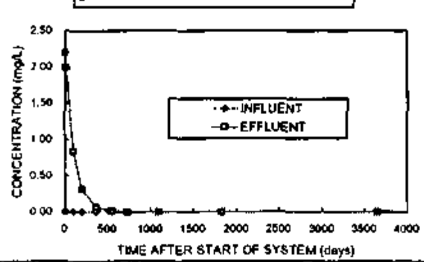
$C_{w(in)}$= 0 lb/ft³

$C_{w(in)}$= 0 mg/L

Y= -9.68E-03 1/day   Y = $Y = \dfrac{-[Q/V_T + k(X_w + P_s Ks) + Q_a/V_T Kh\ z]}{(X_w + P_s Ks + X_a Kh\ z + X_o Ko)}$

B= 0.00E+00 lbs/ft³ day   B = $B = \dfrac{Q/V_T C_{w(0)}}{(X_w + P_s Ks + X_a Kh\ z + X_o Ko)}$

ESTIMATED AIR SPARGING PERFORMANCE



Time years	Time days	$C_{w(t)}$ (mg/l)	$C_{a(t)}$ (mg/m³)	SYSTEM(a) MASS	TRENCH GW CONC.	TRENCH Air Conc	TRENCH Oil Conc	TRENCH SOIL CONC.	INFLUENT(b) (lbs)	BIO.(c) (lbs)	VENTED(d) (lbs)	EFFLUENT(e) (lbs)
				MASS BALANCE (lbs)								
	0	2.200	36	77.6	12.8	0.1	0.0	64.8	0.0	(2.3)	3.9	3.3
	10	1.997	33	72.8	13.9	0.0	0.0	58.8	0.0	(0.2)	23.6	19.9
	100	0.836	14	29.5	4.8	0.0	0.0	24.6	0.0	(1.4)	10.7	9.0
	200	0.318	5	11.2	1.8	0.0	0.0	9.4	0.0	(1.8)	5.8	4.9
1	365	0.064	1	2.3	0.4	0.0	0.0	1.9	0.0	(0.6)	1.3	1.1
1.5	547.5	0.011	0	0.4	0.1	0.0	0.0	0.3	0.0	(0.1)	0.2	0.2
2	730	0.002	0	0.1	0.0	0.0	0.0	0.1	0.0	(0.1)	0.1	0.1
3	1095	0.000	0	0.0	0.0	0.0	0.0	0.0	0.0	(0.0)	0.0	0.0
5	1825	0.000	0	0.0	0.0	0.0	0.0	0.0	0.0	(0.0)	0.0	0.0
10	3650	0.000	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	5475	0.000	0									
				Total	0.0	0.0	0.0	0.0	0.0	-6.3	45.6	38.4

Note:

(a) Initial Mass = GW mass + Soil Mass + Oil Mass + Vapor Mass = $C_{w(t)} * V_T * (X_w + (P_s * Ks)) + C_{a(t)} * X_a * V_T + X_o * Ko * V_T$

(b) Influent Mass = $C_{w(t)}$ * Qi * (Time)

(c) Biodegraded Mass = Initial mass - Final mass + Influent Mass - Vented Mass - Effluent Mass

(d) Vented Mass = $C_{a,avg(t)}$ * Q_a * (Time)

(e) Effluent Mass = $C_{w,avg(t)}$ * Qi * (Time)

O2 Delivered
Q*0.0175 lbs o2/ft3 air* zb
157.5 lbs O2/day

Saturation O2
8 mg/L*Qw
1.248 lbo2/day

Consumed per day
3.5lb 02/lb HC degraded
0.00 lbo2/day

Total Mass O2 required
1.25 lb o2/day

Air flow Required to have 0 excess
1424.09 ft3/day
0.04 cfm/well

TABLE 9
TYPICAL AIR SPARGING PERFORMANCE, FIRST ORDER BIODEGRADATION RATE, VC (Cleanup Time Calculations)

Assumptions

Aquifer Conditions

	Value	Units	Conditions	Stands For
Q_i=	2500	ft³/day		Groundwater flow rate
V_T=	463,050	ft³		Plume Area * Sat. Thickness
X_a=	0.05			Fraction of Air
P_s=	102	lb/ft³	Dry basis	Density of Soil
X_w=	0.20		Porosity	Fraction Water
X_s=	0.75		Solids	Fraction Soil
X_o=	0			Fraction Oil
zv=	0.05			Efficiency factor
Q_a=	180,000	ft³/day		Air Flow Rate

Contaminant

	VC	Units	Stands for
Kd=	0.000	ft³/lb	Soil Partition Coefficient
Ko=	3.91		Oil Partition Coefficient
k=	0.6200	/day	Decay Rate (based on pilot study)
Kh=	50.0000	dimensionless	Air Partition Coefficient (Henry's)

Equations

Cw(t)=((YCw(0)+B)*exp(Yt)-B)/Y

Ca(t)= Kh z Cw(t)

$C_{w(0)}$= 0.000143 lb/ft³

$C_{w(0)}$= 2.3 mg/L

$C_{w(in)}$= 0 lb/ft³

$C_{w(in)}$= 0 mg/L

Y= -3.33E+00 1/day

B= 0.00E+00 lbs/ft³ day

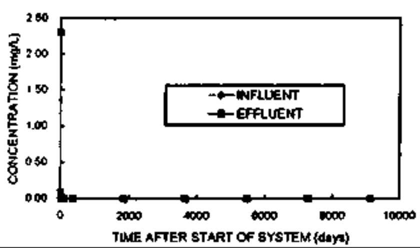
Y =

B =

$$Y = \frac{-[Q_i/V_T + k(X_w + P_s Ks) + Q_a/V_T\, Kh\, z]}{(X_w + P_s Ks + X_a Kh\, z + X_o Ko)}$$

$$B = \frac{Q_i/V_T\, C_{w(0)}}{(X_w + P_s Ks + X_a Kh\, z + X_o Ko)}$$

ESTIMATED AIR SPARGING PERFORMANCE



Time years	Time days	$C_{w(t)}$ (mg/l)	$C_{a(t)}$ (mg/m³)	SYSTEM(a) MASS	TRENCH GW CONC.	TRENCH Air Conc	TRENCH Oil Conc	TRENCH SOIL CONC.	INFLUENT(b) (lbs)	BIO.(c) (lbs)	VENTED(d) (lbs)	EFFLUENT(e) (lbs)
	0	2.300	5,750	22.1	13.4	8.3	0.0	0.4	0.0	(12.3)	33.5	0.2
	1	0.082	205	0.8	0.5	0.3	0.0	0.0	0.0	(9.6)	10.4	0.1
	10	0.000	0	0.0	0.0	0.0	0.0	0.0	0.0	(0.0)	0.0	0.0
	100	0.000	0	0.0	0.0	0.0	0.0	0.0	0.0	(0.0)	0.0	0.0
1	365	0.000	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	1825	0.000	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	3650	0.000	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	5475	0.000	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	7300	0.000	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	9125	0.000	0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
30	10950	0.000	0									
				Total	0.0	0.0	0.0	0.0	0.0	-21.8	43.8	0.2

MASS BALANCE (lbs)

Note:

(a) Initial Mass = GW mass + Soil Mass + Oil Mass + Vapor Mass = $C_{w(t)} * V_T * (X_w + (P_s * Ks)) + C_{a(t)} * X_a * V_T + X_o * Ko * V_T$

(b) Influent Mass = $C_{w(t)}$ * Qi * (Time)

(c) Biodegraded Mass = Initial mass - Final mass + Influent Mass - Vented Mass - Effluent Mass

(d) Vented Mass = $C_{a,avg(t)}$ * Q_a * (Time)

(e) Effluent Mass = $C_{w,avg(t)}$ * Ql * (Time)

O2 Delivered
Q*0.0175 lbs o2/ft3 air* zb
157.5 lbs O2/day

Saturation O2
8 mg/L*Qw
1.248 lbo2/day

Consumed per day
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Total Mass O2 required
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